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THE PRESENT ASPECTS OF THE PANAMA CANAL.

By Wm. H. Burr.

The construction of the Panama Canal is the largest practical undertaking involving the use of excavating and conveying machinery which is before the engineering world today. Professor Burr reviews the subject altogether in his private and individual capacity; but as a member both of the Isthmian Canal Commission of 1899 and of the present Commission charged with the construction of the waterway, he stands in the forefront of the engineers who are thoroughly familiar with the elements of the problem and the conditions to be met.—THE EDITORS.

INASMUCH as it is scarcely nine months since the present Isthmian Canal Commission was created, and as the first month and a half of that time was nearly wholly occupied in its first visit to the Isthmus for the purpose of inspecting the work about to be acquired by the United States, any view of the Panama Canal project at this early date must be a consideration of what has been transmitted from the new Panama Canal Company to the United States government rather than a review of plans adopted or of methods of construction for the great work undertaken. Indeed, it must be borne in mind that the title of the Panama Canal property was actually transferred to the United States government only on May 4, 1904, so that the Commission has been in control of the canal property but seven months at this writing.

The full report of the former Isthmian Canal Commission of its work performed "with a view to determining the most practicable and feasible route for" a ship canal across the American Isthmus, is a complete compendium not only of all data existing at that time regarding the canal property, but also a comprehensive statement of the plans and estimates of that Commission regarding the type of canal recommended by it. The conditions under which the canal is to be built and the character of the ocean traffic to be accommodated have

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changed so radically within the period elapsed since the old Panama Canal Company went into bankruptcy that the work before the present Isthmian Canal Commission must necessarily be largely independent of anything hitherto contemplated, and its plans must be developed and completed for practically an entirely new project. This is a necessary procedure for a number of important reasons. Among others, during the past three years, even, material developments in the size and motive power of steamships have been made and those developments are in active progress at the present time. Steamships over 700-feet long have been built and there are already serious statements from ocean transportation companies regarding the building of ships approaching 800 feet in length. Loaded vessels have entered or left the harbor of New York with a draft of 32 or 33 feet and possibly a little more. For these general reasons, the former Commission prescribed a bottom width of 150 feet for the canal and a depth of water of 35 feet. Although it is not probable that the greatest ships afloat will, immediately after its completion, seek the Panama Canal, it is practically certain that the opening of such a canal will shift some lines of ocean traffic and stimulate others, so that it is a measure of wisdom only to follow the instructions given to the former Commission and tacitly at least to the present Commission, to construct a waterway which shall afford accommodation for the largest ships afloat.

The Panama Canal line will be practically identical with that first adopted by the old Panama Canal Company and subsequently accepted by the new Panama Canal Company. There will certainly be some modifications of details of alignment, but in the main the French location was well considered and the canal will be built upon it. There is still an open question as to the advisability of what is known as the Tiger Hill alternative, which was so strongly advocated by the late Mr. George S. Morison, member of the former Commission. This alternative line was originally surveyed and located by Commander Lull, U. S. N., in 1875. It covers that portion of the canal location between Gatun, about six miles from Colon, and Bohio, about 17 miles from the same point. It is a shorter line than the French location by about one mile and a quarter. It also has the advantage of moving the canal line away from the Chagres River to the foot of the high ground easterly of that river, and throughout a portion of its length materially higher than the low marshes along the course of the river. It has two disadvantages; one, that the excavation of the old Panama Canal Company between Gatun and Bohio would be abandoned, necessitating a correspondingly increased amount of new ex-

cavation; and the other, that the canal prism would be carried for a considerable distance between Tiger Hill and Bohio within an embankment attaining a height in some places of nearly or quite 20 feet and resting on soft ground. The necessary data for the determination of this and other features of modified alignment have been already largely secured, enabling such questions to be satisfactorily answered in the near future.

The total length of the Panama canal between six-fathom curves in the two oceans is 49.09 miles, of which about 17 miles on the Caribbean side and 8½ miles on the Pacific side, i. e., practically one-half the length of the canal, is to be excavated through low marshy ground little above sea level. These two portions of the line constitute the Atlantic and Pacific sea levels in the plans of the new Panama Canal Company as well as of the former Isthmian Canal Commission. This is an important feature of the project, especially in considering ultimately whether a sea-level canal or canal with locks shall be built, for it indicates that in any event a little more than one-half of the canal will be a sea-level waterway. Will it then be advisable to give to the remainder (less than half the length) the same freedom from restriction of locks to navigation?

The intermediate 24 miles of canal line cover the higher portions of the low saddle in the Cordillera at the Panama crossing. The highest point in this saddle before any excavation was made at Culebra was about 330 feet above mean sea level. The length of this deepest canal cutting through Culebra Hill is scarcely 3,000 feet. Strictly speaking, the heavy part of the summit cut, comprising what is ordinarily known as the Emperador and Culebra Cuts, is not more than six miles in length and its original surface elevation with the exception of the Culebra portion averages about 175 feet above mean sea level. The natural slope from the Culebra Cut toward the Pacific is relatively abrupt, it being but four miles from the cut to Miraflores, at which both the former Commission and the new Panama Canal Company located their first lock on the Pacific side of the Isthmus. The slope from the northerly end of the summit cut at Emperador toward the Caribbean is relatively gentle, the distance from Emperador to Bohio, where the new Panama Canal Company and the former Commission located the first lock on the Caribbean side of the Isthmus, being sixteen miles. No well developed plans for either of the terminal harbors have been made up to this time but such plans are now being thoroughly considered by the present Commission.

The old Panama Canal Company which began its operations in 1881 planned a sea-level canal having a depth of water of 29.5 feet

and bottom width of 72 feet. It carried on work actively until 1889 when it suspended operations and went into bankruptcy, its excavations amounting to a total of about 72,000,000 cubic yards. The new Panama Canal Company has excavated about 8,000,000 cubic yards since that time. The work of excavation of the old company was distributed over parts of the entire line, although there were considerable portions of the line on which no excavation at all was made. Over some other portions of the location relatively small quantities of material only were taken out. The largest parts of this work were performed within about 12 miles of Colon, within about 5 miles of Panama, and within a distance of about 7 miles including the great Culebra and Emperador Cuts. The excavation along the sea-level portions of the canal at either end was all made in soft ground, but in the excavation in the Emperador and Culebra Cuts as well as at Obispo, near the point where the Chagres River first cuts the line of the canal as it flows toward the sea, considerable rock was found, some of it being dense and hard. In addition to this work of actual excavation, the French companies, especially the new Panama Canal Company, accumulated a large amount of available information regarding the subsurface material and depth of bed rock at many points along the line. The examinations, including jet borings at the proposed Bohio and Gamboa dam sites and for the proposed dam at Alhajuela higher up the river, are included in this portion of their operations. The performance of this large amount of excavation work and the investigations disclosing information regarding the subsurface materials, have largely revealed with certainty the character of the greater part of the work to be done in completing a ship canal. In other words, they reduce materially those exigencies of such a great work which consume time and add to the cost.

Of the total excavation hitherto made and amounting to about 80,000,000 cubic yards, probably not more than one-half will be available in the construction work to be planned by the present Commission. This, however, constitutes an available asset of much value.

There is another asset available to an uncertain extent in the immense quantity of material and plant left largely in well kept warehouses but otherwise spread along the entire line in an exposed condition. The apparent book value of all this material as shown in the records of the new Panama Canal Company is about $29,000,000. By far the greater part of this value is now imaginary only. A considerable part of the plant and a large amount of the material in the warehouses can, however, be brought into condition of much value as the work progresses. Indeed, several of the old bucket dredges, a

large number of dump cars, and various other plant, including a most useful machine shop at Matachin, have already been repaired and put into service by Mr. John F. Wallace, the chief engineer of the Commission. The present Commission has thus come into control of a great ship-canal work, a small portion only of which has been performed, and with the greater part of the data required for the ultimate solution of all its problems yet to be determined. These problems include first of all the answer to the main question, whether the canal shall be a sea-level canal or of the lock type. Whether one type or the other be adopted, they cover also such great features of the work as the interior harbor at the Colon or Cristobal entrance to the canal and possibly the exterior harbor lying outside of it, the control of the Chagres River in times of flood, involving the construction of probably a great dam at Bohio or at Gamboa and possibly a tunnel through the Cordillera to divert the waters of the Chagres River toward the Pacific Ocean, additional harbor facilities at the Ancon or Panama end of the canal, the elevation of the summit level if a canal with locks should be built, and the number, location, and lift of those locks. Manifestly, the solution of some of those problems must depend upon the rate at which excavation can be made either in rock or in earth and its unit cost. Further than this, in the event of building a lock canal it is highly probable that a great dam will be required across the Chagres near Bohio, whose construction would involve unprecedented methods upon a large scale in consequence of the great depth of bed rock at that place.

Preparation for construction was begun by the Commission last May by organizing engineering field parties which sailed from New York during June and the early part of July. At the same time Mr. John F. Wallace, formerly general manager of the Illinois Central Railroad Company, past president of the American Society of Civil Engineers, was appointed chief engineer of the Isthmian Canal Commission, and he entered upon his duties the latter part of June. There were five of these parties beside the engineering force organized for the purpose of designing and constructing water works and sewer systems for the cities of Panama and Colon.

Taking these forces in the order of their location from Cristobal, the American port at the Caribbean end of the canal, the first is located at that point. This party is charged with the duty of making all the requisite surveys and investigations, including jet borings, both on land and water, needed for the development of the complete plans for the interior harbor at the mouth of the canal, for the deep-water channel leading to it from the harbor of Colon, and for any advisable re-

alignment of that portion of the canal between Cristobal or Colon and Gatun about six miles inland. The second party was entrusted with the surveys and investigations required to determine the feasibility of building a dam across the Chagres valley at Gatun and to ascertain whether it is desirable to confirm the location of the French companies between Gatun and Bohio, or to adopt the Tiger Hill alternative between those points. The third party has undertaken to make exhaustive investigations, including surveys, necessary for the location of a dam across the Chagres near Bohio, also to make certain other surveys connected with some minor details of re-location in the same general vicinity. This party is making many jet borings on a number of profiles so as to secure complete information regarding the deep bed rock under the river. In this manner the most favorable location for the Bohio dam, should it be constructed, may be conclusively determined. The fourth party has been assigned to the responsible duty of making extensive surveys and other investigations from Gamboa, where the Chagres River and canal line intersect about 30 miles from Colon, 12 miles or more up the Chagres valley. This work will cover the continental divide at the summit of the Cordillera, the southerly limit of the Chagres watershed, and the divide constituting the northerly limit of the same shed; it will include also the numerous borings to bed rock at the Gamboa dam site and at other points. It will disclose the information requisite for the determination of plans for effectively controlling the flood flow of the Chagres River. The data already obtained show that it is entirely feasible to build a dam at Gamboa and to divert a portion, or all, of the waters of the Chagres to the Pacific through a tunnel not more than 7 miles long, or toward the Caribbean Sea through a tunnel piercing the other divide and about 4 miles long, the former probably being preferable. The surveys of the French companies failed to disclose any location for a tunnel less than 10 miles long through the Cordillera towards the Pacific.

The new Panama Canal Company had a labor force of about 700 men engaged in excavation at the great Culebra Cut when the canal property was turned over to the present Commission in May last. The organization of this force and plant has been maintained and greatly increased in efficiency. The fifth field party was assigned to such engineering work in connection with this great excavation as will be required for its ultimate execution and in making the final location in the vicinity of Culebra. This force has also been instrumental in installing a system of field accounts, so that a complete daily record may be kept of progress and cost of all classes of work.

All of these parties have conducted the operations assigned to them continuously and energetically. They have secured data of great value in the ultimate solution of the main problems of the project. They are still at work in their several fields, but these preliminary operations are drawing to a close, thus enabling the Commission promptly to study and formulate the final plans on which the work of construction on a large scale depends.

The United States government is required under the treaty made with the Republic of Panama not only to construct complete water works and sewer systems for the cities of Panama and Colon, but also to formulate and execute certain sanitary measures for those cities. In accordance with the terms of the agreement recently reached by Secretary Taft with the Panama government at the city of Panama, complete control of this sanitary work has been vested in the United States government represented by the Isthmian Canal Commission.

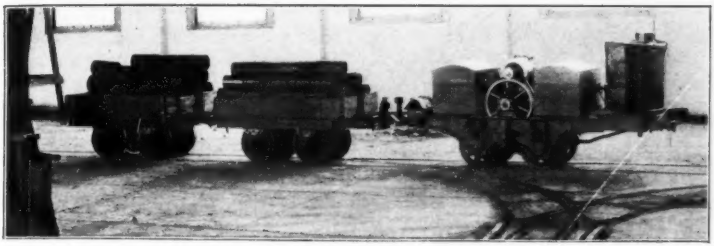
The source of public water supply selected for the city of Panama is a reservoir in the upper Rio Grande valley close to the great Culebra Cut and about 10 miles from the city. The dam for this reservoir was constructed in the days of the old Panama Company by M. Philippe Bunau-Varilla, chief engineer, and subsequently the first Minister Plenipotentiary from the Republic of Panama to the United States. This is an interesting example of a curved concrete dam built in a few days time and containing little masonry, yet it has proved admirably adapted to its purpose. This dam will be raised and strengthened so as largely to increase the capacity of the reservoir. A 16-inch cast-iron pipe will convey the water to a distributing reservoir at Ancon, in the canal zone, at a suitable elevation on the north-eastern slope of Ancon Hill immediately adjacent to the city of Panama. The supply has been based upon an estimated daily consumption of 60 gallons per head of population. The distribution system is complete in every particular and adapted to any extension required by the future growth of the city. The construction of this water-works system has progressed so far as to render it practically certain that the city will receive the first public water in its history in February next.

The planning and construction of the sewer system has also been pushed forward as rapidly as possible and it will be completed ready for use soon after the introduction of water. The sewer system is divided into three districts, each having an outfall into the sea water of Panama Bay, at a sufficient distance from the shore to provide abund-

ant dilution. The system is designed to receive the sewerage of the city and a rainfall of about one inch per hour, any excess over the latter being carried off on the surface. When it is remembered that the city of Panama has never before had a sewer system it can readily be appreciated what a sanitary relief both the sewer system and the water supply will be to the city.

The water-supply and sewer systems for the city of Colon have also received the careful attention of the Commission. A suitable source of water, however, has not been so easy to find as at Panama, and the sewer system cannot be constructed until a considerable amount of filling with excavated material from the canal has been completed. Both works, however, will be undertaken and finished in the near future. As the population of Colon is under 6,000 while that of Panama is nearly 20,000, the conditions bearing upon the sanitation of Colon are the more easily controlled pending completion of its water works and sewers.

It may be interesting to observe, although not in line with the actual construction of the canal, that the Commission among its other duties is charged with that of the civil government of the canal zone, a territory 10 miles wide running across the Isthmus with the axis of the canal as its center line, but excluding the cities of Panama and Colon as delimited under the treaty. Major Gen. George W. Davis, U. S. A., retired, member of the Isthmian Canal Commission, is the Governor of the zone, and under his jurisdiction have been organized by the Commission most effective hospital and sanitary forces with Col. W. C. Gorgas, U. S. A., as chief sanitary officer. The great hospital on the slope of Ancon Hill with its 700 beds has been put in excellent working condition, while the sanitary forces of the Commission have already rendered highly effective services toward bringing the entire zone into sanitary condition, especially in the extermination of mosquitoes. Boards of health of high character and excellent quarantine organizations have been established both at Panama and Colon. Although four sporadic cases of yellow fever have occurred in Panama within the last six months, the infection has not spread from any case, in consequence of the vigilance of the medical and sanitary forces. The general health of the Isthmus has been good and there seems to be a certain promise of excellent sanitary conditions hereafter, such as to enable the forces of the Commission to perform their work in safety from epidemics and with the highest degree of efficiency obtainable in the tropics.



Robins Storage-Battery Locomotive in the N. Y. Subway Power House.

MECHANICAL TRANSPORTATION IN THE MODERN MACHINE SHOP.

By Frederick A. Waldron.

This article is not intended by its author to be a technical discussion of the design and construction of the numerous appliances as used in the different methods of shop transportation, but a historical and descriptive treatise on the principal forms of hoisting apparatus as utilized in the modern machine shop.

A NOTED authority on rapid transit stated, a few years ago, "that it was not a struggle for minutes, but for seconds, that would solve the problem." The aggregate capital invested in industrial corporations far exceeds the amounts invested in rapid-transit facilities in large cities, and the problem of "rapid transit" in the modern machine shop is as far-reaching as in the large city.

Thirty years ago, the owner of a machine shop was an investor, who, by prudence, earned a livelihood, or, from some patented monopoly, made a fortune. Today this is changed. The owner of the larger machine shop is a banker, endeavoring to turn his capital over as many times as possible during a year, expecting only a fair interest return on the money which is loaned on labor and materials. To accomplish this result, each unit of product which goes to make the whole must be gotten out of the way as quickly as possible, in order to make room for the next.

Modern methods of management demand prompt and efficient service for the elaborate and expensive machinery in which the owner's money is invested. Further, the systems now in use in compensating employees are such that in order to obtain the best possible

results and accurate costs, the element of unforeseen contingencies must be eliminated as far as possible. To accomplish this, brain and muscle are brought to bear on the problem from every direction. The introduction of high-speed steels and the phenomenal increase in the weights of machinery, combined with the premium and piece-rate systems for the purpose of decreasing prime labor costs, are becoming universal; the whole aim is an increased output on plant investment.

The manufacturer of today who is investing heavily in new machinery and high-speed steels, but who does not take into consideration the most efficient methods of mechanical transportation, places his shop in the same position as the freight-storage yard of a large railroad, if left without a switch engine. Of what value are the modern machines and rapid-production methods if a piece of work remains in a machine longer than is required to perform the necessary operations? A terse definition of mechanical transportation, as applied to the machine shop of today, is, "To get what you want, where you want it, when you want it;" and as a general proposition it is wanted right away. To accomplish these results, the traveling crane, industrial railway, jib crane, tram rails, elevators, and chain hoist have assumed as important a place in the modern machine shop as have the high-speed steels and machine tools.

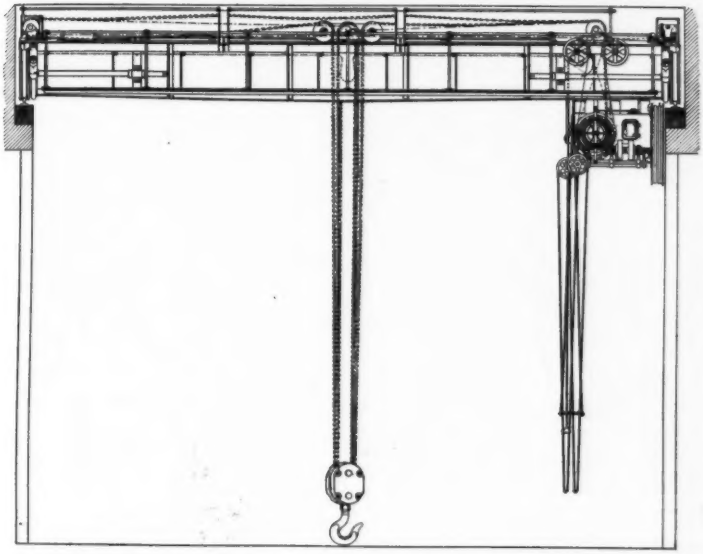
For convenience, the subject will be divided as follows:—

1.—Historical.

2.—Descriptive. { a Types of Hoists and their characteristics. / b Selection. / c Care and Inspection.

3.—Commercial Efficiency.

Historical.—It is not more than twenty-five years ago that the chief organs of mechanical transportation, exclusively resorted to by the machine shops of that period, consisted of a crowbar, screw-jack, a few skids, and gas pipe or hard-wood rollers. The first step in the systematic treatment of the shop-transportation problem was the differential chain hoist, hung from an improvised trolley, gantry, or tram rail. Prior to 1880 there was no systematic attempt in the United States to classify and manufacture, as a regular product, cranes of any description. In 1881-82, the first attempt in this direction was made by Henry R. Towne, who, in a paper read before the American Society of Mechanical Engineers and later published by him in book form (in 1883) brought the classification of cranes to a rational and commercial basis.



FIRST TRAVELING CRANE BUILT BY THE YALE & TOWNE MFG. CO., STAMFORD, CONN., U. S. A.

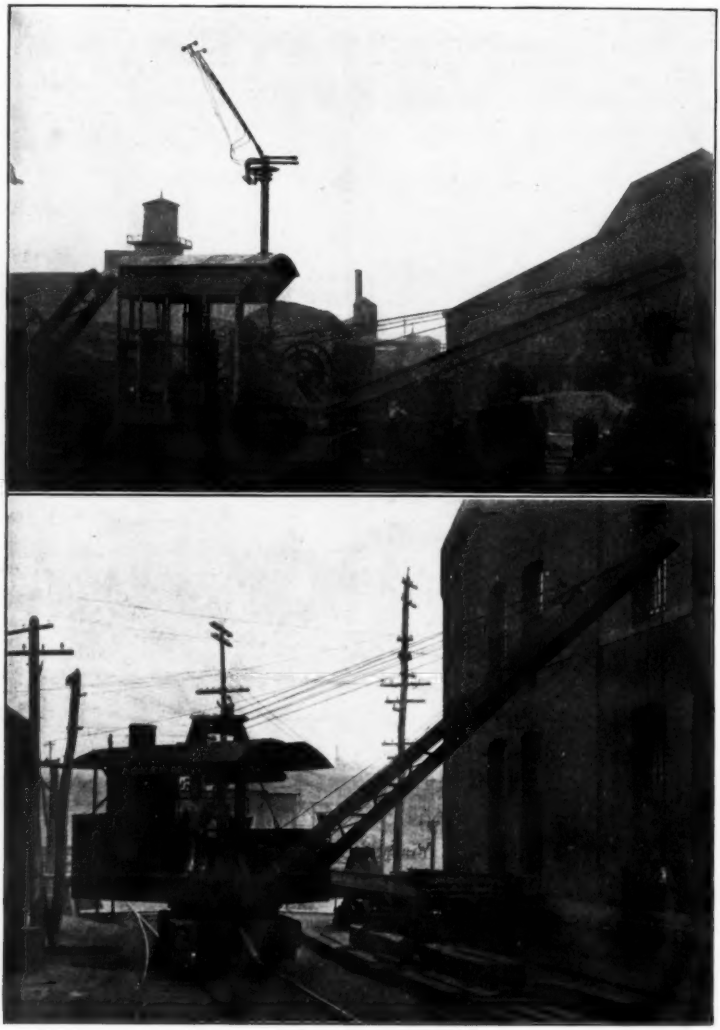
Built in 1882, being one of the first in the United States. Received power from a cotton rope, running the entire length of the shop and driving the rope wheel on the right; trolley travel and hoisting effected by a pitched chain running over pocket wheels; bridge travel by "squaring rope" method, the rope passing around a grip wheel in the crab mechanism.

The locomotive crane and various types of traveling cranes had been made for some years prior to this in England and on the Continent, but Mr. Towne's paper is the first record of any systematic attempt to produce cranes commercially in the United States. Since then the evolution of the power traveling crane has been very rapid, and the epoch-making periods date as follows:—

In 1880-82 the first power travelers were designed with rope drive, squaring rope for bridge travel, and pitch chain for hoisting and trolley travel.

One of the first power travelers manufactured in the United States is shown just above and was built in November, 1882.

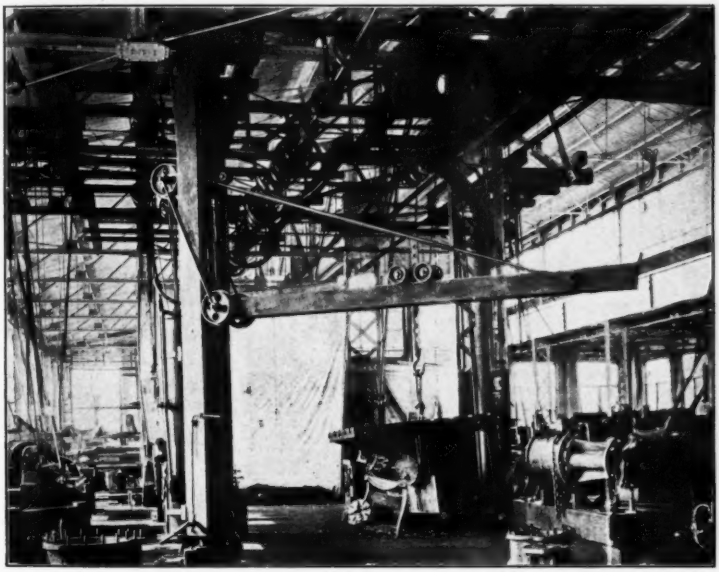
In 1885-88 the square shaft and "tumbling bearings" were substituted for the rope drive; the squaring rope was eliminated, and the truck wheels of the bridge were connected with a pinion shaft, while a self-contained trolley, with hoisting drum contained thereon, was driven by a shaft extending across the bridge.



TYPES OF LOCOMOTIVE CRANES.

The crane in the upper picture, built by the Brown Hoisting Machinery Co., is operated electrically in all its functions—hoisting, rotating, and traveling. The one below, built by the American Hoist & Derrick Co., St. Paul, Minn., is steam-driven; it has a 30-ft. boom, and is of 15-tons capacity at 10-ft. radius. It is shown as installed in the Allis-Chalmers works, Scranton, Pa.

From 1889 to the present day, the traveling crane has been developed exclusively along electrical lines. The first electric crane was built by the E. P. Allis Company, from a design by Alton J. Shaw, who founded the Shaw Electric Crane Company, of Muskegon, Mich., and many of the features contained in this first design are used by the leading crane makers of today. From that time to the present day, the energy of the crane builder has been devoted to the perfection of design and refinement of construction, together with increased wearing capacity for continuous and heavy duty.

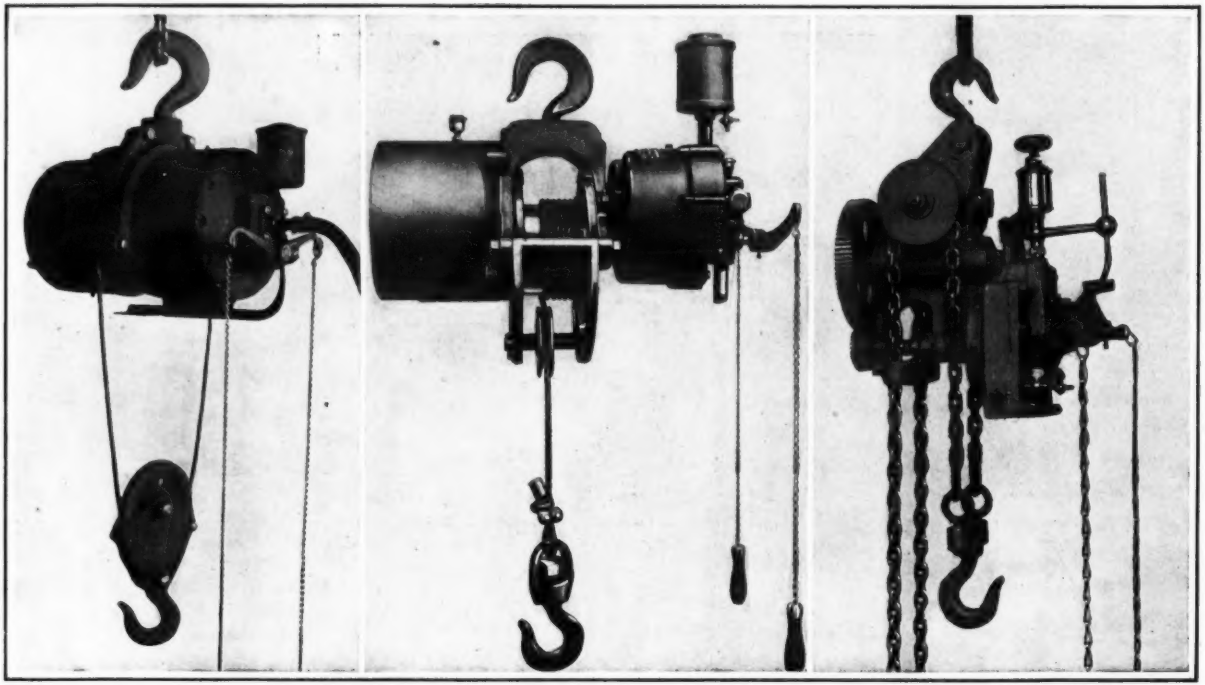


A HYDRO-PNEUMATIC JIB CRANE, FOR FOUNDRY AND SHOP USE.
Power is applied by putting air-pressure on the water in a cylinder at the back of the crane. The water is forced through a valve and under the plunger of a cylinder between the uprights of the jib, giving a very smooth and even lift.
The Pedrick & Ayer Co.

Hand traveling cranes have undergone less change than the power travelers, although the details of design have been somewhat improved, and different hoisting devices have been substituted for the heavy trolleys and winches which were used in the earlier styles.

The jib crane has changed only in minor details of design, and, with one or two exceptions, remains as it was twenty-five years ago.

The locomotive crane is made much heavier and more durable,



TYPES OF PNEUMATIC HOISTS FOR SHOP, FOUNDRY, AND GENERAL USE.

On the lett, the regular pneumatic-motor wire-rope hoist made by the General Pneumatic Tool Co., Montour Falls, N. Y.; in the center, the pneumatic geared hoist of the Chicago Pneumatic Tool Co.; on the right, a pneumatic chain hoist made in sizes from 1 to 10 tons by the Dake Engine Co., Grand Haven, Mich.

and is designed for both steam and electricity, but since 1889-90 very few radical changes have been made in the general design of the steam locomotive crane. The application, however, of electricity as a motive power, has necessitated a locomotive crane of special design.

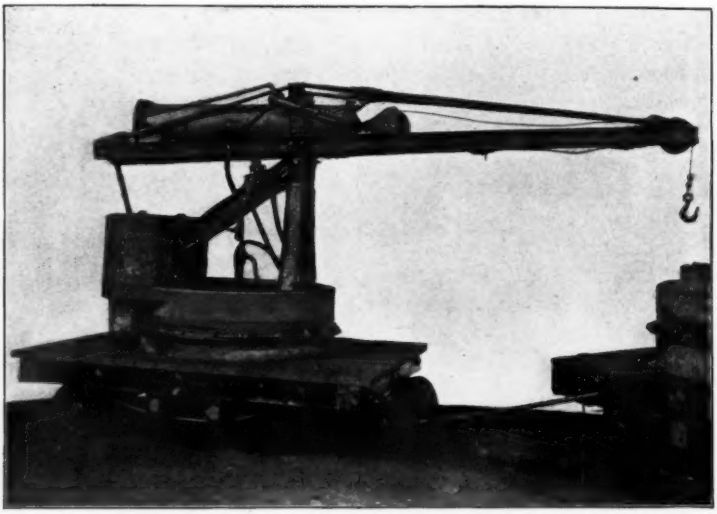
Chain Hoists.—The earliest and simplest form of chain hoist is known as the "Weston Differential Block," and was invented in the later fifties, reaching its final stage of perfection about 1864. A few years later the screw hoist appeared as a very formidable and successful competitor.

It was not until 1887-89 that the losses by friction in the differential and screw hoist were fully realized, when, at that time, Mr. Thomas A. Weston, working under the direction of Mr. Henry R. Towne, and assisted by the writer, developed the spur-gear hoist, which is known today the world over as the "Triplex Hoist." Its efficiency exceeds the differential and screw hoist about 250 per cent., the former having 80 per cent. where the two latter average about 30 per cent. In other words, the spur-gear type of hoist is over two and one-half times as efficient as any form of differential or screw hoist. Since that time, numerous forms of spur-gear hoists have appeared, both in England and the United States, all of them, however, adopting the same principle for sustaining the load. The action of any of these hoists depends entirely upon the quality of workmanship and the degree of nicety with which the lowering device is designed and made and its chains are fitted. Since 1890, there has been very little change in the general design of spur-geared types of hoists, and it has been the aim of the manufacturers to improve the quality of materials, workmanship, smoothness of action, durability, and strength.

Electric Hoists.—With the advent and perfection of the electric motor and its application to hoisting apparatus, the demand for a light, high-speed hoist has been growing, until, within the last four years, several forms of electric hoists have been placed on the market. Some of these are shown on pages 501, 510, 511, and 512.

Air Hoists.—The air hoist has been developed along the lines which the market has demanded, but except in foundry work, to which it is peculiarly adapted, it is not generally as popular as the electric hoist. It is used in the plunger and motor form, in places where electricity is not obtainable, or where the work requiring the use of the hoist will not warrant the expense of an electric installation.

The single-lift pneumatic cylinder hoist finds special application to work requiring smoothness of motion and freedom from jar, and



A PORTABLE PNEUMATIC JIB CRANE, 1,000-POUND CAPACITY, 7-FEET REACH.
Garry Iron & Steel Co., Cleveland, Ohio.

not requiring great exactness of range in the vertical lift. In spite of the low efficiency and inconvenience of the air motor, it has found favor in many places. The development dates from 1889 to 1890.

Hydraulic Hoists.—The hydraulic hoist is the result of the demands for a hoist of this character for use in certain places where neither air nor electricity could be used to advantage. The reliability of this hoist, where water is not liable to freeze, is such as to make it very desirable for certain cases. For general work, however, it is not to be compared with the electric hoist. The hydraulic hoist has never gone beyond the cylindrical or plunger design, and its selection depends upon environments.

Types of Hoists and their Characteristics.—Hoisting-machinery may be divided into two general classes—cranes and chain hoists.

Cranes.—Cranes, as applied to modern machine-shop practice, may be concentrated into the following types:—

(a) Traveling cranes (hand or power) which are intended to cover any point in any given rectangular space.

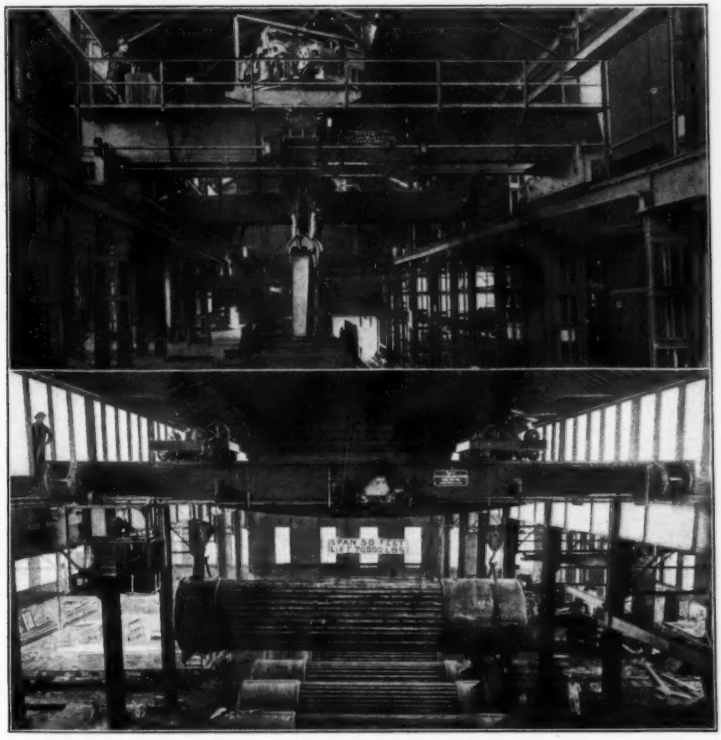
(b) Jib cranes (hand or power) which are intended to cover any point within the area of a given circle.

(c) Locomotive cranes (steam or electric) which are intended to cover given areas either side of a narrow or broad-gauge railroad track, in the machine shop or the factory yard.

The jib crane may be designed to perform the functions of the locomotive crane within a given area of the machine shop, but is not adapted for use where buildings do not give opportunity for supporting the top pintle.

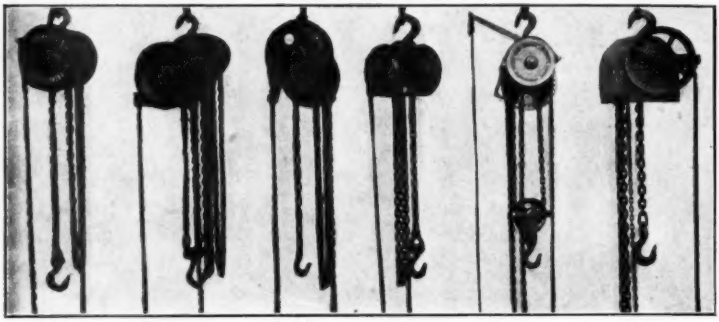
Chain Hoists.—The chain hoist is a portable machine which automatically sustains the load at any given point of its hoist and allows the load to be either lifted or lowered at the will of the operator, by pulling in one direction or the other on what is termed the "hand chain." It takes its name from the fact that the load is suspended on a chain passing over a pocket wheel, and the mechanism is also operated by a chain passing over a pocket wheel.

This type of hoist has grown from a luxury to a necessity in the modern machine shop, and is used exclusively in places that cannot



ELECTRIC OVERHEAD TRAVELING CRANES IN USE.

In the ingot crane, above, the hoisting mechanism is rotated on the trolley; Case Mfg. Co., Columbus, O. The crane below is double-trolley type, 50-ft. span, 35-ton capacity; Cleveland Crane Co., Wickliffe, O.

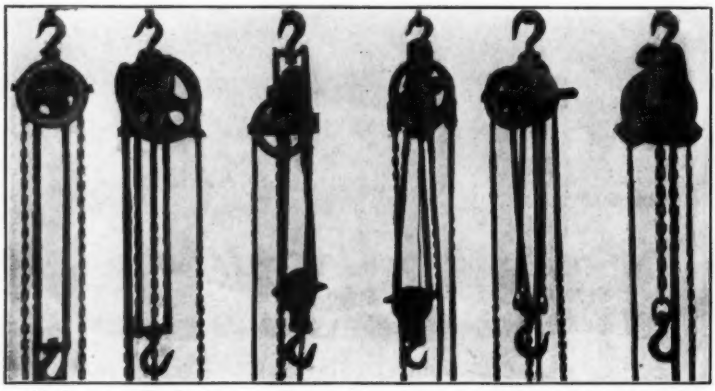


Triplex. Keystone. Facile. Speidel. Cherry. Victoria.

SPUR GEAR HOISTS.

The makers are:—Triplex, Yale & Towne Mfg. Co.; Keystone, E. Harrington, Son & Co.; Facile, Tangyes, Ltd.; Speidel, J. G. Speidel; Cherry, Tangyes, Ltd.; Victoria, unknown, but of English make.

be reached by the power traveling crane. In fact, so universal has its use become that a majority of hand travelers and jib cranes, of sizes from ½ ton to 20 tons, are equipped with this mechanism. It has many advantages over what is termed the "crab" and "winch" design of the earlier forms of hand travelers and jib cranes, inasmuch as the mechanism is self-contained and can be easily removed, in case of repair, and replaced by another; it is inexpensive, its cost of maintenance slight, and its efficiency is higher than it is possible to obtain by either the "crab" or "winch."



Duplex. Harrington. German. Acme. Moore. Boston & Lockport.

SCREW AND DIFFERENTIAL HOISTS.

Makers:—Duplex, Yale & Towne Mfg. Co.; Harrington, E. Harrington, Son & Co.; German, unknown; Acme, Franklin Moore Co.; Moore Anti-Friction, Chisholm & Moore; Boston & Lockport, Boston & Lockport Block Co.

SPEEDS OF HOISTING WITH VARIOUS TYPES OF HOISTS.

	Spur-Gear Hoist. Feet per Minute.				Screw Hoist.		Differential.	
Tons.	Full Load.	Half Load.	Quarter Load.	No. of Men.	Feet per Minute.	No. of Men.	Feet per Minute.	No. of Men.
¼	...	....	....	..	....	..	6.	1
½	8.	16.	24.	1	4.	1	6.	2
1	4.	8.	12.	1	2.	1	3.70	3
1½	4.8	9.6	14.4	2	2.40	2	2.50	3
2	3.6	7.2	10.8	2	1.80	2	2.30	4
3	2.3	4.6	6.9	2	1.10	2	2.30	7
3½	...	....	....	..	.95	2	....	..
4	1.7	3.5	5.2	2	.80	2	....	..
5	1.3	2.6	3.9	2	.65	2	....	..
6	1.1	2.2	3.3	2	.50	2	....	..
7	...	....	....	..	.40	2	....	..
8	.8	1.6	2.4	2	.35	2	....	..
10	.6	1.2	1.8	2	.30	2	....	..
12	1.1	2.2	3.3	4	....	..	....	..
16	.8	1.6	2.4	4	....	..	....	..
20	.6	1.2	1.8	4	....	..	....	..

	Weight in Pounds. One man can hoist at 80 lb. hand-chain pull.			Hand-Chain Pull. In lbs. to lift full load.			Ft. of Hand Chain. To be operated to lift 1 foot.		
Capacity in Tons.	Spur Gear.	Screw Hoist.	Differential.	Spur Gear.	Screw Hoist.	Differential.	Spur Gear.	Screw Hoist.	Differential.
¼	....	....	500	...	...	72	...	...	18
½	1000	1000	600	62	68	122	21	40	24
1	2000	1700	800	82	87	216	31	59	30
1½	2300	2500	1000	110	94	246	35	80	36
2	2600	2700	1100	120	115	308	42	93	42
3	4000	3300	1000	114	132	557	69	126	38
3½	....	4000	....	...	140	...	...	138	..
4	5000	4600	....	124	142	...	84	155	..
5	6500	5300	....	110	145	...	126	195	..
6	7000	6500	....	130	145	...	120	252	..
7	....	7000	....	...	160	...	...	275	..
8	9000	7800	....	135	160	...	168	310	..
10	11000	10000	....	140	160	...	210	390	..
12	13000	....	....	260	...	...	126	...	..
16	17000	....	....	270	...	...	168	...	..
20	20000	....	....	280	...	...	210	...	..

The speeds are given for short lifts with men accustomed to the work; for continuous easy lifting, two-thirds of these speeds should be obtained. Quick and easy lifting comes from working the chain hand over hand, avoiding useless and fatiguing body motion. Many good workmen could save themselves much time and labor by observing this.

The Spur Gear Hoist lifts rapidly and the speed increases for light loads because the amount of hand-chain to be overhauled is small and the speed does not exceed that at which a man can move his arms.

Selection of Hoisting Apparatus.—Volumes might be written on the selection of hoisting apparatus for the modern machine shop, with the probability that very few of the suggestions would be applicable to the case which an engineer might have in hand. The points which govern the selection of a hoist are varied in their make up, and depend largely on local requirements and conditions, and relation to the ultimate efficiency of the shop; so much so, that in the selection of any commercial type of hoist the immediate economy in labor-saving is so small, as compared with the commercial efficiency of the plant, that it could be almost ignored. In other words, the selection and installation of transportation facilities for the modern machine shop should always have a broad-gauge investigation and supervision, beyond the question of immediate economies in labor-saving. A few of the points, however, which may prove of value to those who anticipate the purchasing of hoisting apparatus are as follows:—

1.—The capacity for continuous operation.

2.—The character of the work on which the hoist is to be used.

3.—The frequency with which loads are to be lifted.

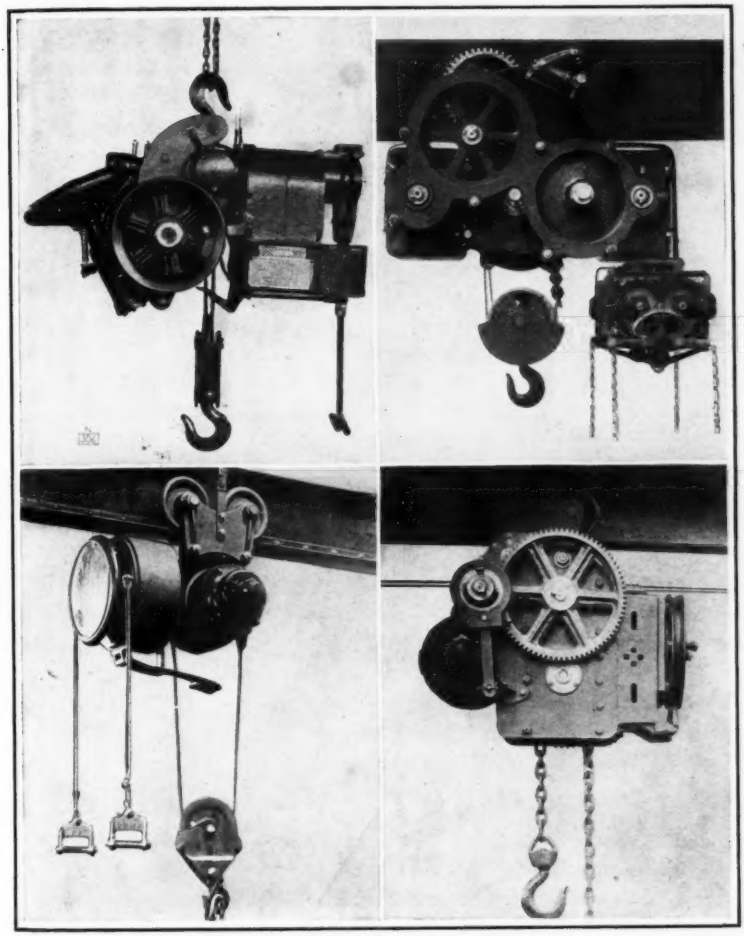
4.—The speeds best adapted for the work.

5.—The cost of maintenance.

At the present time, it is of paramount importance that the machinery of transportation in the modern machine shop shall be always ready to do its work. While mechanical efficiency, with minimum power consumption, is to be desired (where the cost of power is high), yet it is a secondary consideration as compared with the certainty of having the apparatus always ready for use. This is particularly applicable to high-class apparatus using either steam or electric power. On the chain hoist, however, where high-class labor is often called upon to remove work from the machines, the hoist of the highest mechanical efficiency and speed is not only desirable but imperative.

The characteristics of the work on which a hoist is to be used govern its selection more largely than any other one point. On this depends not only the first cost of the hoist, but also its life and commercial efficiency.

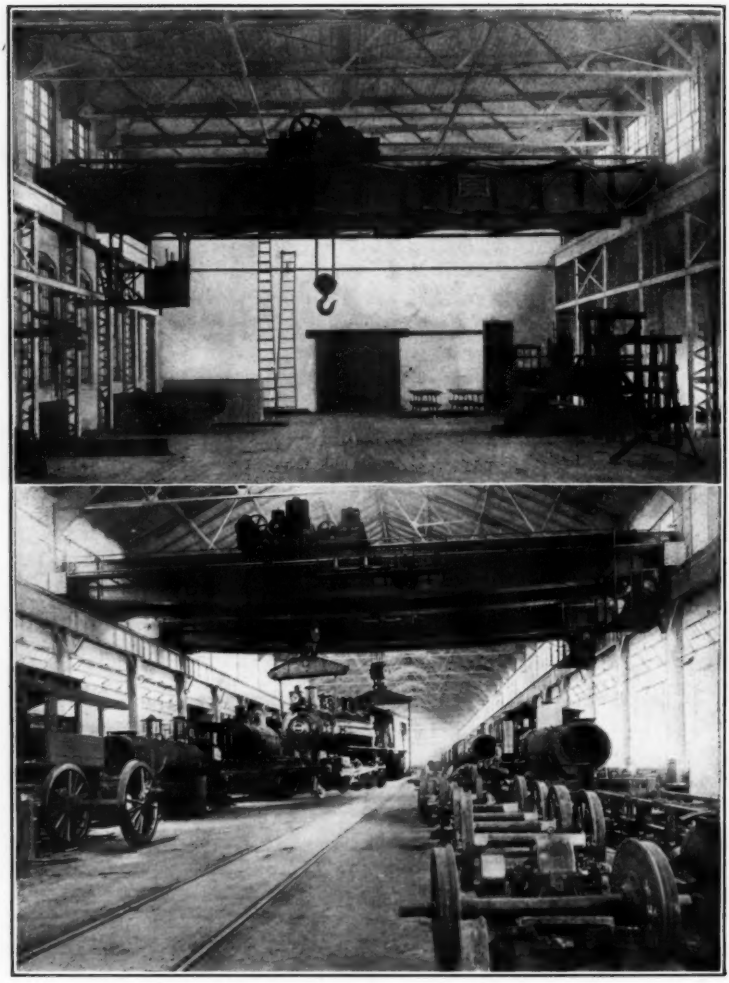
The number of lifts which a hoist is to make, per unit of time, is another important consideration. As an illustration:—A shop requires a 20-ton hoist, intending to lift a 20-ton load once or twice a month, while the average load lifted may be 10 tons lifted once or twice each day. It would be poor business judgment to select an expensive, high-speed, power hoist for work of this character. On the other hand, where a hoist is to lift its full capacity a number of times each hour, during the day, it is much better to install a hoist of 25 to 50 per cent.



A GROUP OF CHARACTERISTIC ELECTRIC HOISTS.

The upper figure on the left is a 2-ton hoist made by the Yale & Towne Co., Stamford, Conn.; immediately to the right of that is a 1600-lb. hoist, 8-ft. hook lift, by Pawling & Harnischfeger, Milwaukee, Wis.; the lower figure on the left is 1-ton hoist made by the General Pneumatic Tool Co. Montour Falls, N. Y.; that in the lower right-hand corner is by the Cleveland Crane & Car Co., Wickliffe, Ohio. The last three are of the electric trolley type.

greater capacity than is required, in order to insure against the element of wear and tear which must ultimately result from the continuous working of the mechanism to its full rated load, at too frequent intervals.



EXAMPLES OF MODERN ELECTRIC-CRANE INSTALLATION.

The upper figure shows a single trolley crane, using chain instead of wire rope for hoisting. The lattice girder form gives lateral stability with a minimum of material. Built by Brown Hoisting Machinery Co. The cranes in the locomotive works shown in the lower view may be used singly when the load admits, or doubly (as shown) for heavy loads. Wire ropes are used in the hoisting element. Span 76 ft. 4 in.; maximum hoist 75 tons, with auxiliaries of 10 tons each near the ends. Shaw Electric Crane Co., Muskegon, Mich.

Speeds of Hoists.—The speeds of a hoist should be carefully selected for the work it is intended to perform. For instance, a crane devoted to the handling of structural material in the yards or assembling shops can be speeded from 50 to 100 per cent. above the maximum hoisting speeds shown in Table No. 2. On the other hand, the foundry requires very slow, steady speeds in handling flasks and drawing patterns; while on the assembling-floors, and for placing materials on machines, a slow speed of hoist is also very desirable.

SPEEDS OF HOISTS.

TABLE NO. 1. ENGLISH PRACTICE.

SPEEDS OF ELECTRIC OVERHEAD CRANES.

Speed, with full load, in feet per minute.

Lifting Capacity.	Hoisting. Main.		Auxiliary.	Trolley Travel.	Bridge Travel.
Tons.	Ft.	In.	Feet.	Feet.	Feet.
100	3	6	14	50	80
100	2	0	7	50	60
50	6	0	24	70	125
50	3	0	30	40	80
40	3	0	..	50	80
20	10	0	40	100	200
10	10	0	..	60	150
5	20	0	..	60	150
3	30	0	..	60	150
3	30	0	..	100	325

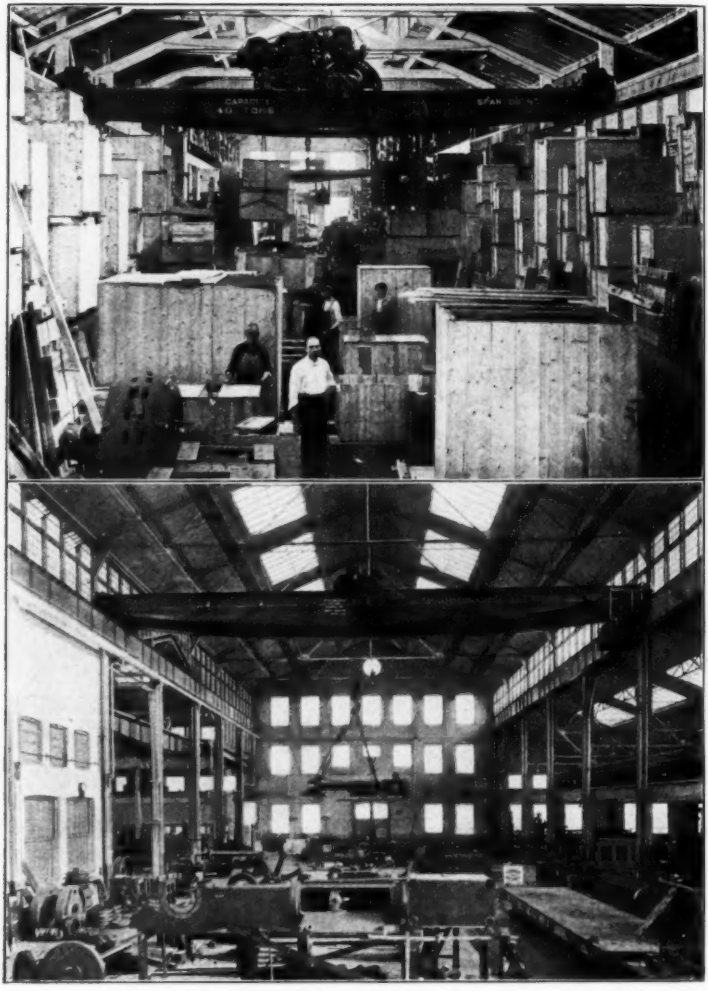
Iron Trade Review, August 17, 1904.

TABLE NO. 2. AMERICAN PRACTICE.

Speeds all in feet per minute.

Capacity Tons (2000 lbs.)	Hoisting. No load Max.	Full load Max.	Trolley travel. No load	Full load Max.	Bridge travel. No load	Full load Max.
5	40	20	125	100	325	250
10	60	24	125	100	325	250
15	28	14	125	100	325	250
20	30	15	125	100	325	250
25	30	12	125	100	325	250
30	20	10	110	90	325	250
40	16	8	110	90	250	200
50	25	10	125	80	300	250
75	18	7	100	80	250	200
100	25	10	125	100	250	200
125	25	10	125	100	250	200
150	18	7	100	80	250	200

NOTE.—The apparent lack of uniformity in tabulated speeds in Table No. 2 is due to the fact that different firms build cranes within ranges of speeds and capacities, and differing sizes built by some are not built, or the speeds are not scheduled, by others. Cranes of 100 tons and above are all of the two-trolley type.



SHOP TRANSPORTATION BY OVERHEAD-CRANE SERVICE.

The upper picture shows the traveling crane applied to the service of the shipping floor, the installation being by the Morgan Engineering Co., Alliance, O., in the Schenectady works of the General Electric Co. The lower view is of a Pawling & Harnischfeger crane in the erecting shop of Nordberg Mfg. Co., Milwaukee; capacity 30 tons, with 5-ton auxiliary; span 80 ft., hook hoist 40 ft.; length of runway 190 ft.; speed of main hoist, 10 to 25 ft., of auxiliary 30 to 90 ft., of bridge travel 200 to 250 ft., and of trolley travel 100 to 150 ft. per minute.

Power Traveling Cranes.—This type of crane, as now manufactured, represents the culmination of energy and skill of the engineer. In the illustrations presented, it has been impossible, on account of the space available, to show all of the various types. Distinctive types, however, have been selected, and brief descriptions accompany each illustration.

A HAND TRAVELER OF 10-TONS CAPACITY IN THE POWER PLANT OF THE YALE & TOWNE CO.

The bridge is of ordinary form with truck ends and trolley traveling mechanism. A standard Yale & Towne triplex hoist is suspended from the trolley; the portability of the hoist permits its removal and use elsewhere in the works, in case of need.

Hand Traveling Cranes.—The hand traveling crane is particularly adapted to places where it is desired to cover a given area with a hoisting apparatus of minimum cost, such as store houses, power houses, assembling floors, and other places where frequent use and high speeds are not absolutely necesary. The only criticism that can be made of the hand traveling crane is that, on account of its low first cost, it is a great temptation to many manufacturers to install it where a power traveler would be much more economical in the long run.

Jib Cranes.—The jib crane can be utilized in almost any place where the building is sufficiently strong to withstand the resulting

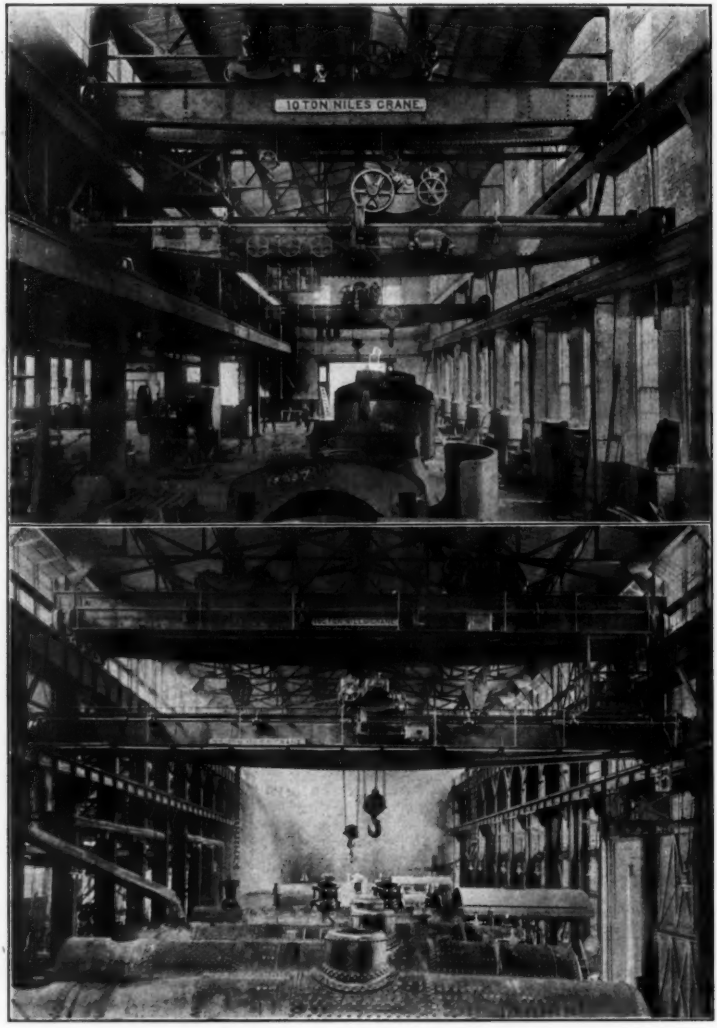
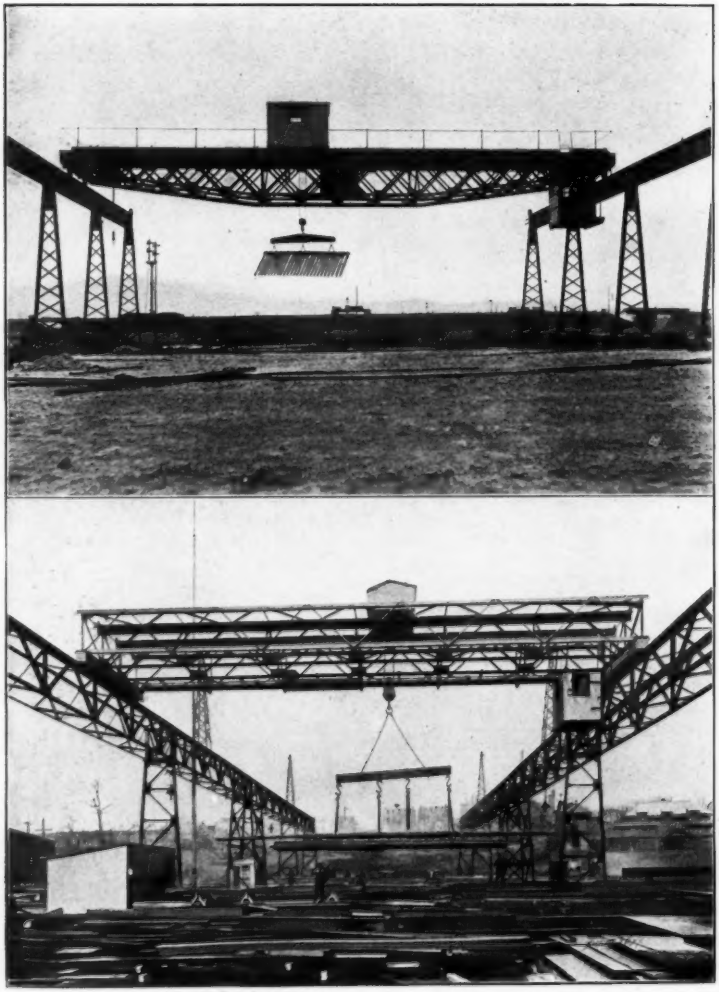


ILLUSTRATION OF THE "DOUBLE-DECK" METHOD OF UTILIZING TRAVELING CRANES.

Both are of Niles-Bement-Pond installation, the upper being in the Cooke Locomotive Works, and the lower in the Rogers Locomotive Works, Paterson, N. J. In the former there is one 10-ton crane with two 5-ton trolleys, and two 5-ton cranes—all of 30-ft. 8-in. span. In the latter there is one 100-ton crane with two 50-ton trolleys, and one 25-ton crane with 5-ton auxiliary; span 65 ft.

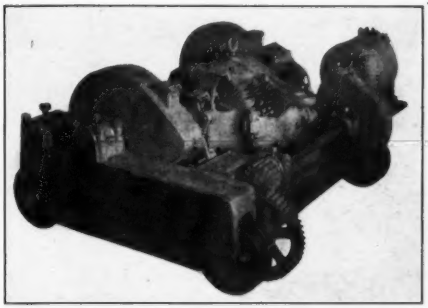
THE TRAVELING CRANE IN OUT-OF-DOORS SERVICE.

The lower illustration is taken from the Schenectady works of the General Electric Co. The combined gantry and cantilever shown in this figure is in use in the loading and shipping department. The two 40-ton overhead travelers in the upper picture are in service in the machine-shop yards of the Allis-Chalmers Co., West Allis works. They have a span of 67 ft., a hook lift of 22 ft., and a length of runway of 660 ft.; 220 volt, direct current.



OVERHEAD TRAVELING CRANES APPLIED TO OPEN-AIR TRANSPORT.

The upper view shows a 5-ton three-motor crane of 75-ft. span built for the Carnforth Hematite Iron Co., Ltd., by Thos. Broadbent & Sons, Ltd., Huddersfield; the speeds are, in feet per minute: hoisting, 60; longitudinal travel, 500; cross travel, 100. The lower view shows a 10-ton yard crane, 270-ft. span, installed by the Niles-Bement-Pond Co. for the Phoenixville Iron Co.; hoisting speed 20 to 40 ft., and travel 250 to 300 ft. per minute.



AN EXAMPLE OF ENCASED TROLLEY.

Applicable to situations where dust and dirt are likely to injuire the working parts. The trolley shown is for a 10-ton hoist; made by the Cleveland Crane & Car Co., Wickliffe, Ohio.

stresses due to the lifting of the required loads. It is especially desirable in the bays and side aisles of the machine shop of modern design, and can also be applied with advantage to the older design of shops, and give increased efficiency in the shop output.

Locomotive Cranes.—This form of crane has, to a large extent, become a necessity in all manufacturing establishments where extensive areas are to be covered in storage yards and shops. Some of the forms are shown on page 492. It will be noted in these forms of cranes that wire rope has entirely superseded the use of chain.

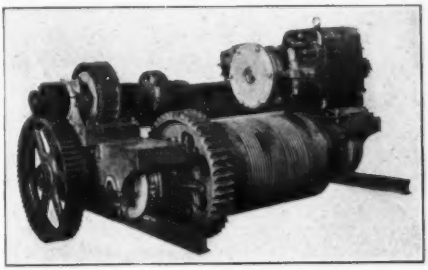
TABLE NO. 3. AMERICAN PRACTICE.

LOCOMOTIVE CRANES.

Lifting Capacity. Tons.	Speed with full load in ft. per Minute. Hoisting.	Traveling.	Speed of Slowing. Complete Revolutions per Minute.
3	135	520	6
5	75	460	5
10	42½	500	4
20	25	300	2½

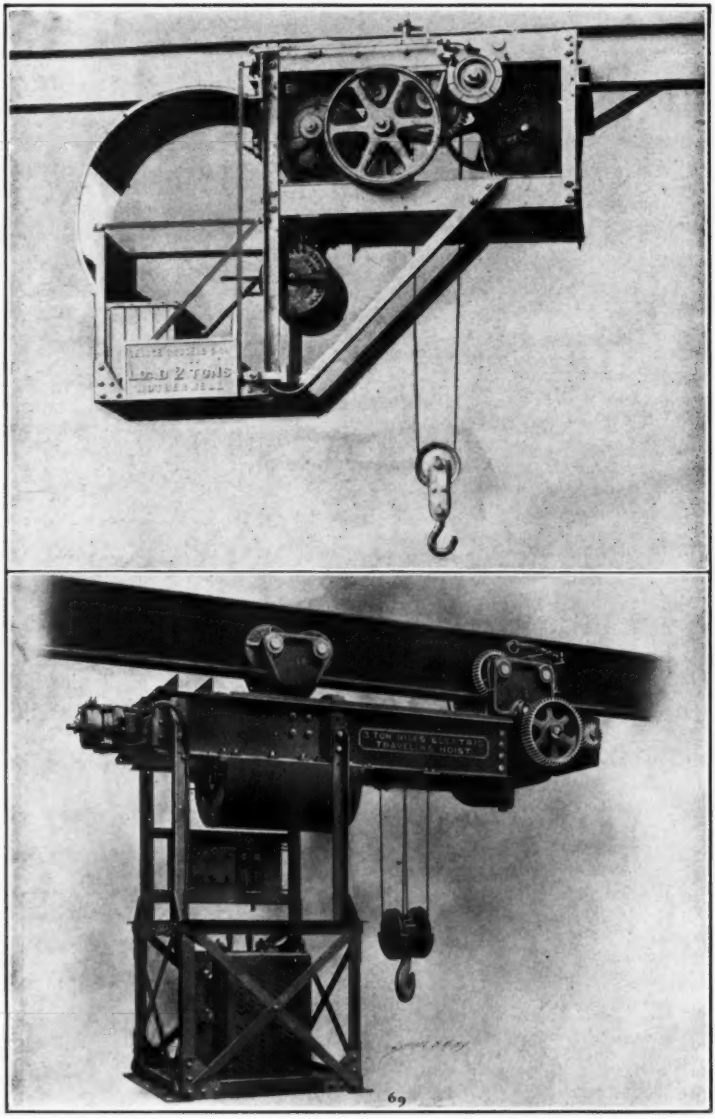
Iron Trade Review, August 27, 1903.

The economy of the locomotive crane depends largely on the crudeness with which materials have been handled before its installation. In some instances it has paid for itself in six months' time. Its minimum economy has been 10 per cent. net on the investment.



AN EXAMPLE OF NON-ENCLOSED TROLLEY.

For use with electric-power traveling crane. Made by the Case Mfg. Co., Columbus, Ohio.

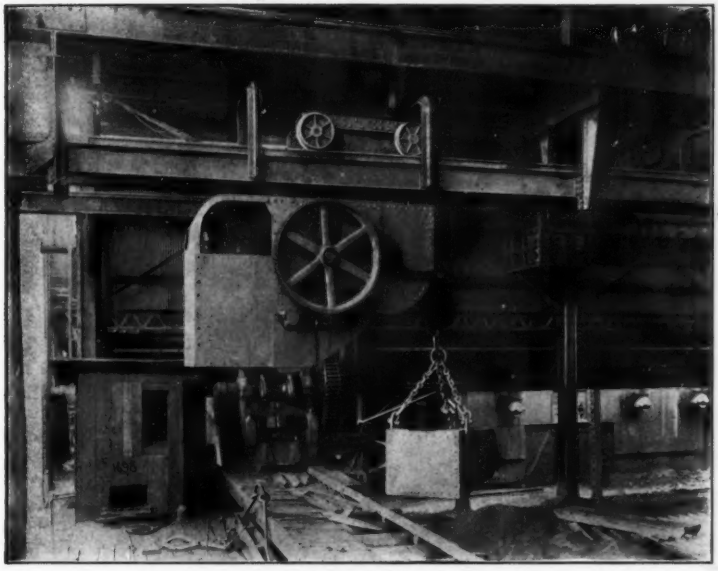


EXAMPLES OF TRAVELING HOISTS WITH TRAM-RAIL SUSPENSION.

In the upper picture is shown a 2-ton electric overhead traveling hoist supplied to Stewards & Lloyds, Ltd., by George Russell & Co., Ltd., Motherwell; in the lower one is seen a 3-ton electric traveling hoist made by the Niles-Bement-Pond Co.

Electric Hoists.—This form of hoist can be properly divided into two classes, the portable and non-portable, distinguished as follows:—

The portable hoist has a single hook suspension and can be readily transferred to any type of crane or trolley, or any form of support of sufficient strength to carry safely the load which it is intended to lift.

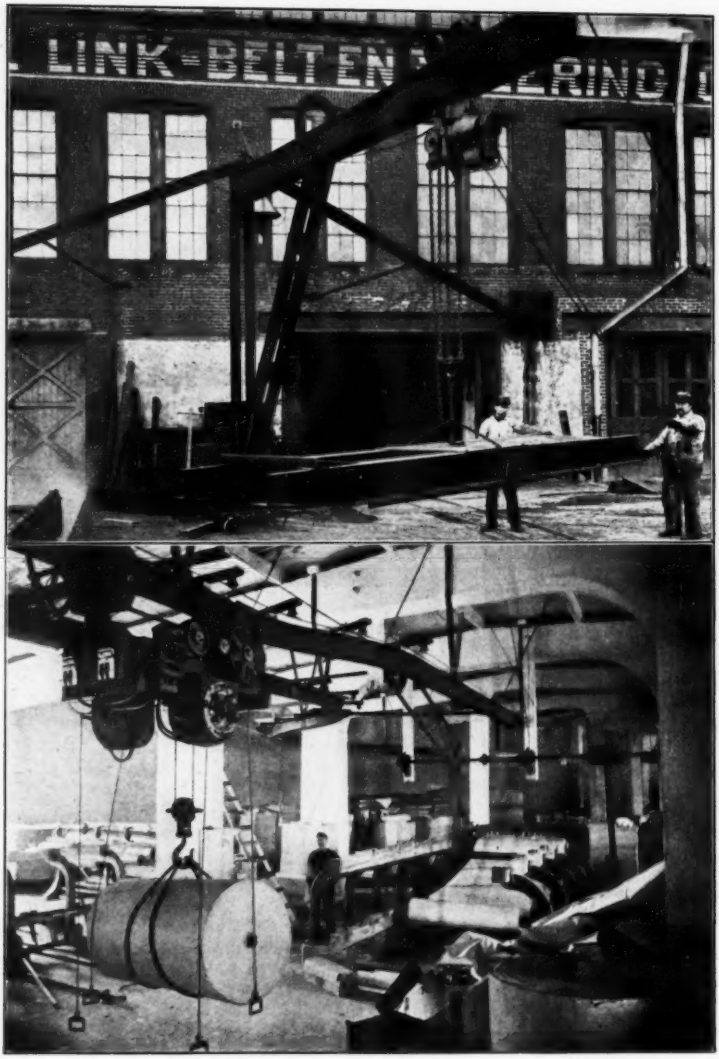


ELECTRIC HOIST AND CONVEYOR.

The Chamberlain patent, as installed by the Link Belt Engineering Co.; from 1 to 5-tons capacity, 40-ft. per minute hoisting speed and 600-ft. trolley speed.

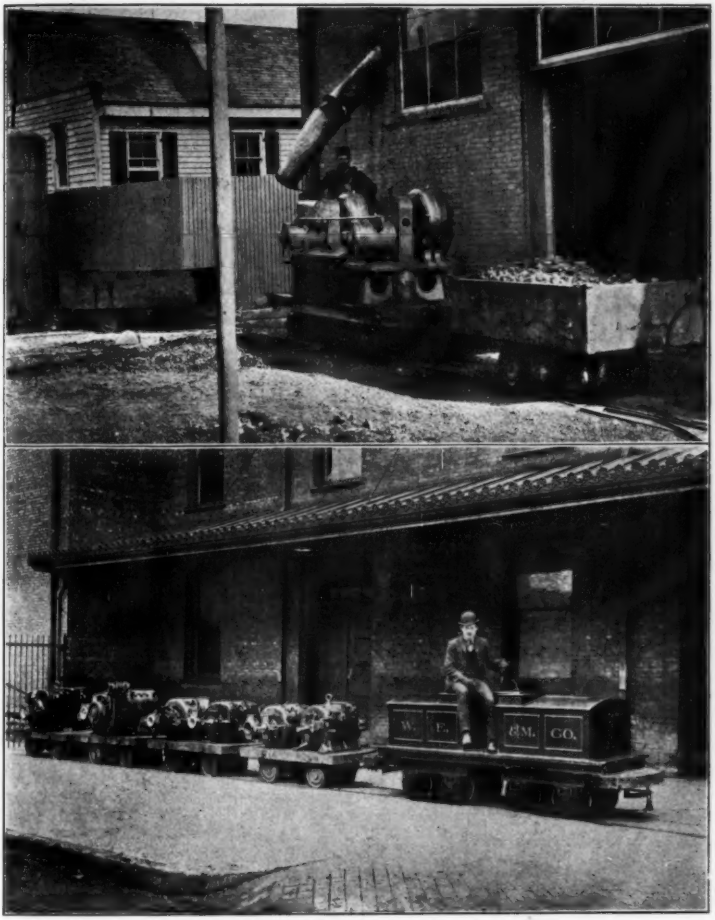
The non-portable form is built into the trolleys, designed to run on the I-beam or other form of tram rail. Of this latter type, three of the figures on page 501 show different forms of the non-portable hoist as operated from the floor. The figures on this page and the one facing show a type of hoist operated from a platform attached to the trolley, which has become very popular for certain classes of work. The portable form of hoist shown on page 501 can be readily taken from one place to another, as conditions may require.

Industrial Railroads.—Thus far, we have considered methods of transportation by which the article to be transported is carried to its destination while suspended in the air. The following illustrations show a slightly different method of obtaining results by the industrial railway, which may be either of narrow or broad-gauge construction.



INSTALLATIONS OF ELECTRIC TROLLEY HOISTS FOR FACTORY TRANSPORTATION.

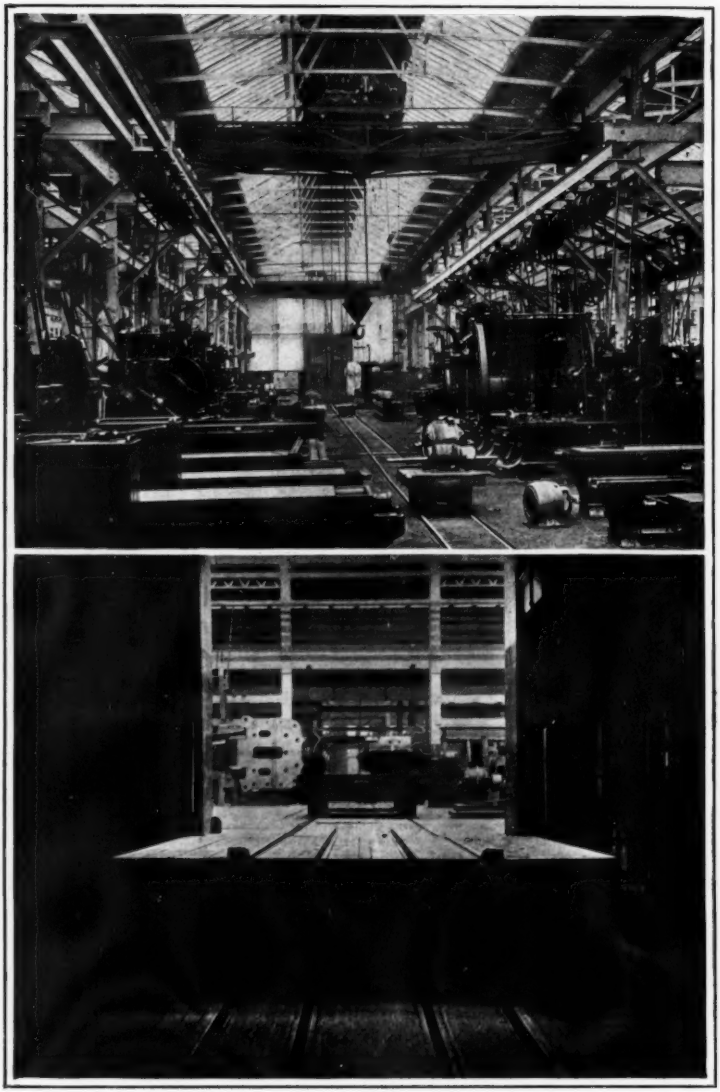
The upper figure shows a Sprague electric hoist mounted on a jib crane in the shops of the Link Belt Engineering Co., Nicetown, Phila.; the lower one shows a two-motor design of 1 to 3-ton capacity, 200 to 300 ft. per minute travel, using 220-volt direct current, made by the Northern Engineering Works, Detroit, Mich.



ELECTRIC LOCOMOTIVES FOR INTERNAL TRANSPORTATION IN THE WORKS.

The upper figure is a C. W. Hunt Co. electric storage-battery locomotive; the lower is a Westinghouse storage-battery locomotive in service in the shops of the Westinghouse E. & M. Co.

As the broad-gauge construction enters into the discussion of freight facilities and other matters which are necessarily outside of the category of machine-shop practice, the accompanying illustrations are intended to represent the typical narrow-gauge industrial system applied to shop work.

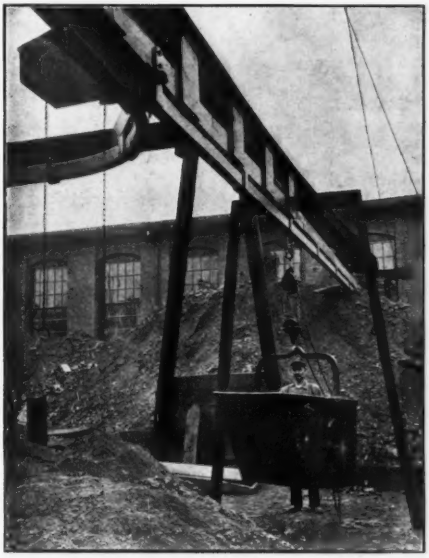


MACHINE-SHOP APPLICATIONS OF THE INDUSTRIAL RAILWAY.

The upper picture is taken in the works of the British Thomson-Houston Co., Rugby; the lower is in Westinghouse E. & M. Co.'s shops, and shows the industrial railway in the center of standard-gauge track, and the elevating table to equalize the difference in level of two floors. Both installations are by the C. W. Hunt Co.

The economy of the narrow-gauge system depends largely upon the crudeness of the methods before employed. In numbers of cases, installations of this character have saved their cost in a year, and, when installed with proper judgment, the industrial railway will undoubtedly pay high interest on the investment.

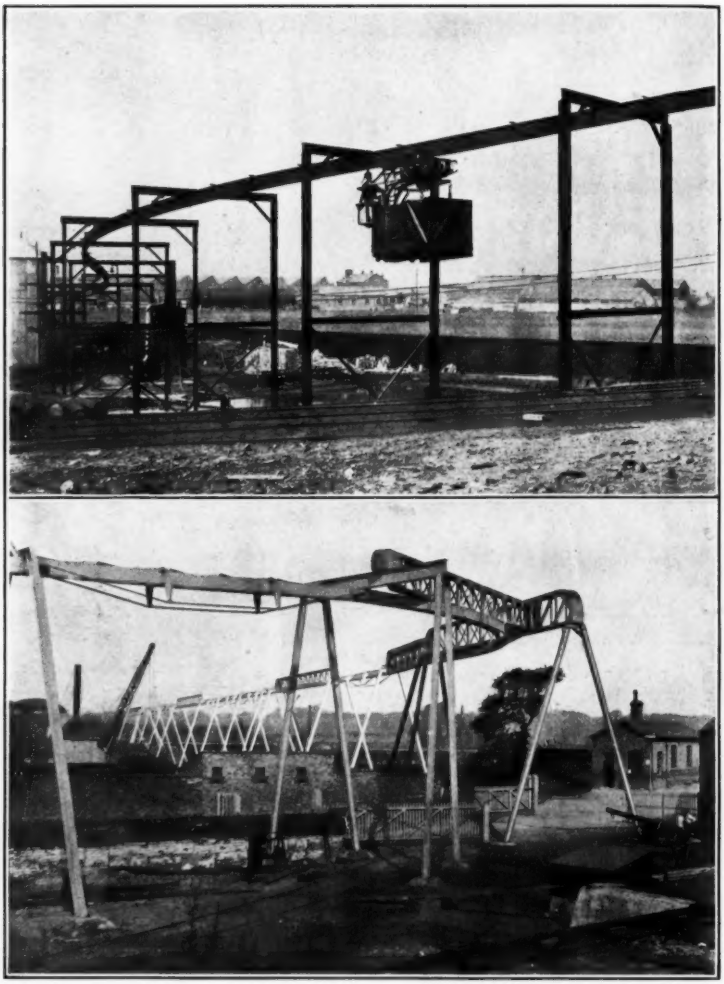
Cost of Maintenance.—It has been impossible to obtain reliable figures as to the actual cost of maintenance of the apparatus which this article describes. Every modern machine shop, however, is equipped, more or less, with cranes and hoists, and the cost of maintenance and repairs must necessarily be very moderate as compared with the results secured. The parts which require most frequent renewals on the modern traveling crane are the axle bearings for truck wheels on the bridge and trolley, brushes, and contact fingers in the controller. Where chains are used for hoisting, the removal and annealing of the chains, with an occasional replacement, are required. Where wire ropes are used as the hoisting element, the renewals of the wire rope (at a comparatively small expense) are all that is required.



THE TROLLEY TRACK IN SHOP TRANSPORT.
Coburn Trolley Track Mfg. Co., Holyoke, Mass.

On chain hoists that are used frequently (where the chain passes over the pocket wheels) it is necessary to renew the chain occasionally, as the wear of both the wheel and the chain will, in time, prevent their working together properly. Replacements from other causes than the above are traceable either to negligence or careless handling on the part of the employee, or to deliberate overloading or abusing of the apparatus beyond its rated capacity.

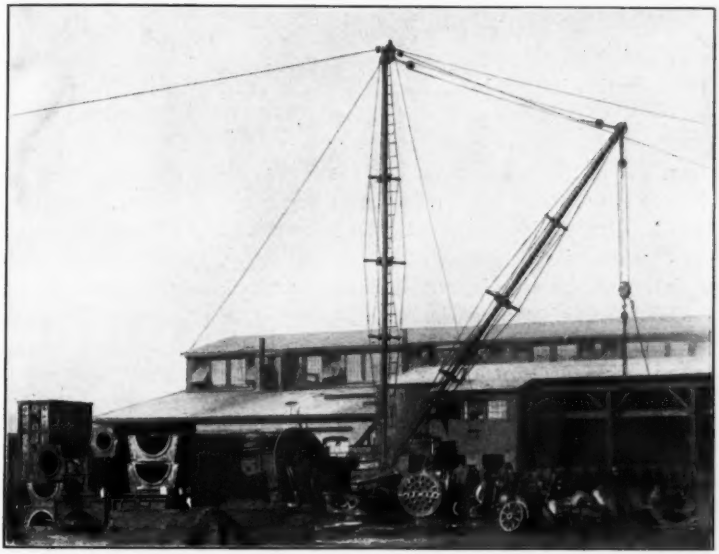
Overloading from careless and improper handling can, to a great extent, be prevented by systematic and careful instructions in the



TWO CHARACTERISTIC EXAMPLES OF MECHANICAL HANDLING BY THE USE OF TRANSPORTERS.

The upper picture shows a Temperley "electric traveling crab" transporter, 1½ to 3-tons load, 80-ft. per minute lift, 800-ft. per minute travel, carrying material from wharf to factory, up a grade of 1 in 13, at the British Fire Lighters Company's works. The lower view shows a transporter built by and used in the works of Andrew Handyside & Co., Ltd., for conveying material between machine shop, rivetting sheds, and erecting shop; it is electrically driven and will carry a load of 10 tons.

method of handling machinery of transportation, and where the number of machines is large and their character varied, the same attention should be given it as to the power equipment of a plant. This system is carried out to quite an extent in the largest and most progressive shops of the day, and applies equally well to a shop with only one small hoist.



THE DERRICK-CRANE ADAPTED TO HANDLING MATERIALS IN THE YARD.

Ten-ton capacity wrought-iron tubular derrick, 55-ft. mast and 50-ft. boom, plant of Henry R. Worthington. Built by American Hoist & Derrick Co., St. Paul, Minn.

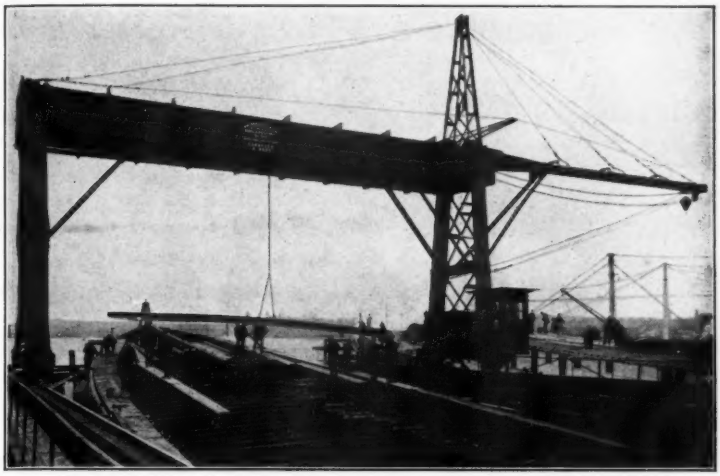
Care and Inspection.—In order to insure against accident, or against appliances being out of commission, systematic inspections should be made on all hoisting apparatus, from the largest and most expensive to the smallest and least expensive—not only because all machinery should be kept in first-class condition, but because of the damage which is liable to occur to life, limb, or property when apparatus is allowed to wear to a point where it will break down. Inspection is especially desirable in the lighter forms of chain hoists, as it is quite frequently the case that, through poor judgment or carelessness on the part of the employee, a hoist is broken and the fact is not properly reported. The next time it is used, some one is seriously hurt or very much frightened, and the number of miraculous escapes from injury

to employees and machinery is surprising in shops where no method of care and inspection has been systematically followed. The principal cases of weakness in an average hoist are generally produced by overstraining at some time, from intentional overloading or from careless handling or abuse on the part of the operator; while inspection will not eliminate this, it will prevent it, many times, before damage has been done.

Commercial Efficiency.—The ultimate value of any shop appliance is its commercial efficiency. By this is meant its participating value in increasing the annual production. The correlations of the productive, non-productive, and contributive elements of the manufacturing plant are becoming so interwoven that it is very difficult, at times, to draw the line between them. In fact, all of the above are the producing elements of a manufacturing organization. It will thus be seen that it would be absurd to attempt to place any definite figures to the credit of the machinery of transportation, as it is so closely allied with the machine tools, the buildings, and the motive power of an establishment, that it can be truthfully said that no shop is complete without them all. It should, therefore, be borne in mind that, whenever a crane or chain hoist is intelligently placed in a position which facilitates the handling of a product, though it may be difficult to see the direct return, it can be assured as a general proposition that it will be a contributor in a greater or less degree toward raising the commercial efficiency of any plant.

Effect on Shop Costs.—With modern methods of production, the elimination of unnecessary delays, etc., is necessary to the last degree. With rapid-production methods on either the premium, bonus, or piece-rate plan, it is absolutely necessary to reduce the element of unforeseen contingencies to a minimum. This necessitates the prompt and immediate serving of every employee, which cannot de done except by systematic and proper study of the transportation problem. Each machine should have its work promptly removed and other work ready to take its place, and the less delay occurring between these changes, the more accurate becomes the record of shop costs.

The amount of fixed charges in the shop of today, and the cost of maintaining the commercial organization, combined with the cost of buildings, equipment, and manufacturing organization, is such that the direct saving in labor cost of handling materials is lost sight of in the increased output of the plant as a whole. This is the most logical view to take on the question of installing appliances for handling materials in the machine shop, and, if systematically planned and car-



5-TON TRAVELING GANTRY CRANE, HARLAN & HOLLINGSWORTH SHIPYARD, WILMINGTON, DEL.

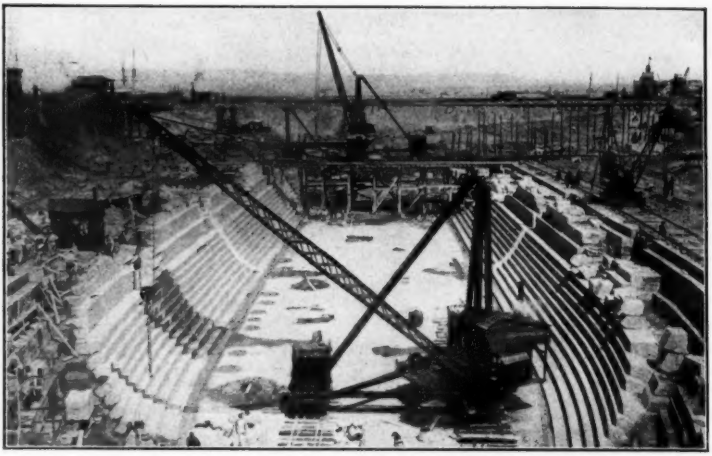
Bridge 70 ft. above ground and 51-ft. span; driven by three variable-speed motors; Wm. Sellers & Co., Inc., Philadelphia, Pa.

ried out, its results will more than satisfy the most sanguine expectations.

In conclusion, the field of mechanical transportation is broader than ever, and should receive detailed study and systematic investigation in whatever place it is to be carried out. It will not do to hang a hoist here and there, at random, and expect to get the best results. The entire problem should be considered as a whole, with the idea that each piece of apparatus installed is a part which goes to make up the grand total of maximum efficiency in the machine-shop output.

OVERHEAD TROLLEY TRACK INSTALLED FOR INTER-COMMUNICATION BETWEEN VARIOUS PARTS OF THE WORKS.

Coburn Trolley Track Mfg. Co., Holyoke, Mass.



Portable cranes and contractors' machinery at work at Gibraltar. John M. Henderson & Co.

EXCAVATING AND CONVEYING MACHINERY IN CONTRACT WORK.

By C. H. Wright.

Mr. Waldron's article dealt with apparatus directly serving the needs of the builder of machinery. Mr. Wright, with like authority born of intimate association with his subject, takes up the devices suited to the work of the constructing civil engineer.—THE EDITORS.

IT is not very many years ago that twenty-five miles an hour was considered satisfactory speed for express trains. Today passengers grumble at the slowness of trains running from fifty-five to sixty miles an hour. Mountains are tunneled and hills leveled down, that a saving of a few miles in distance and a few minutes in time may be effected.

Formerly, if a railroad embankment was to be made, a small army of laborers would be sent to a gravel bank, and the material would be shoveled onto cars and then shoveled off again at the point where the fill was to be made. Today, huge steam shovels and a half-dozen men will load a train of cars in a few moments, and then scrapers operated by machinery, controlled by one or two men, will scrape the material from the cars and dump it in piles along the sides of the track at the point where the new fill is to be made, in even less time than was con-

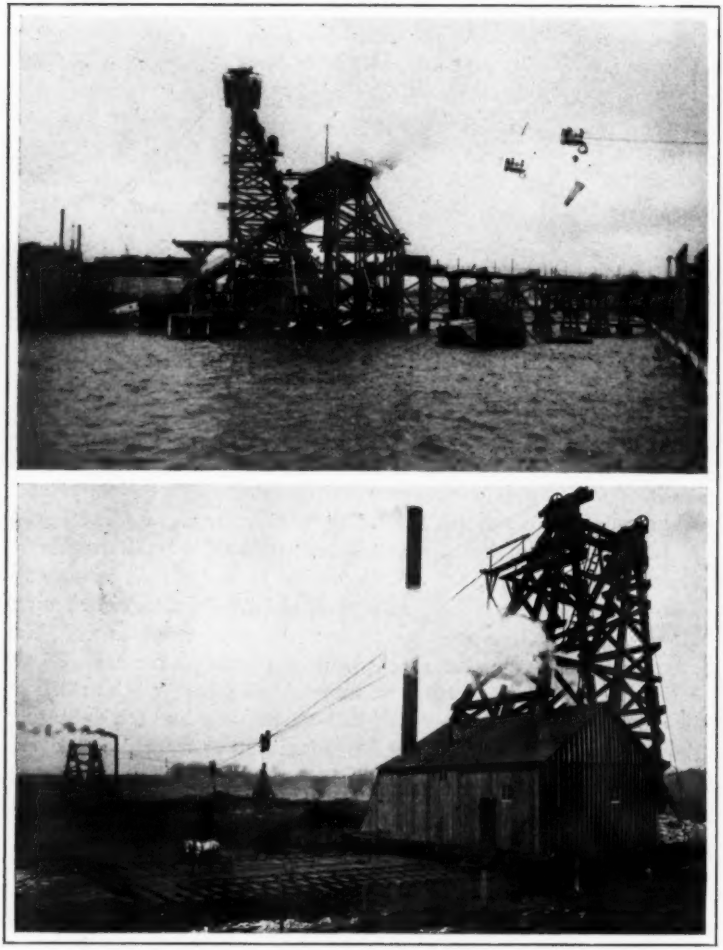
sumed in loading it. Mechanical spreaders, running on the railroad tracks, then come along and spread the material evenly and to any desired depth, over the top and sides of the new embankment. Drainage ditches along the sides of the track are dug and kept in proper condition by ditching machines, which not only remove the material but load it on cars ready to be hauled away.

Railroad bridges of moderate span are built and riveted up complete at the shops, and are then unloaded from the cars by derrick cranes mounted on flat cars, which land the new bridge along the side of the tracks adjacent to its final location, or often place it directly in its permanent and final position on the masonry abutments.

The engineering papers are full of the descriptions of great undertakings, such as tunnels, subways, canals, harbor improvements, and great buildings, many of which would be impracticable or even impossible without the aid of the most perfect machinery and appliances for the rapid, economical, and safe handling of large quantities of material.

Labor-saving appliances are replacing laborers by the thousands; and yet this does not mean, as is being asserted by some, that laborers are being deprived of their means of livelihood. It is capable of demonstration that where one laborer has been deprived of employment by modern machinery, opportunities have been furnished for a half-dozen to obtain more congenial and lucrative employment. If a fifteen or twenty-story building is being constructed, the old methods of conveying brick and mortar on the backs of laborers, who climb on ladders from floor to floor, would be both too slow and too expensive. Elevators moving with speeds of two hundred to three hundred feet per minute now carry this material from floor to floor, and steel beams and columns weighing tons are safely hoisted one hundred feet in the air, and placed in position in a very few minutes, with perfect safety to the half-dozen men who need be employed.

The handling and moving of large quantities of heavy and bulky materials has proved an attractive field for engineers and contractors. This branch of engineering has become almost a separate and distinct line of industry, and has attracted some of the keenest, most able, and perhaps boldest minds in the engineering profession. The results which they have accomplished in this field easily place their work in the front rank, not only of engineering, but also of executive and industrial achievements. The diversity and magnitude of engineering works, which are being carried on by labor-saving machines and appliances, can perhaps best be illustrated by a few examples.



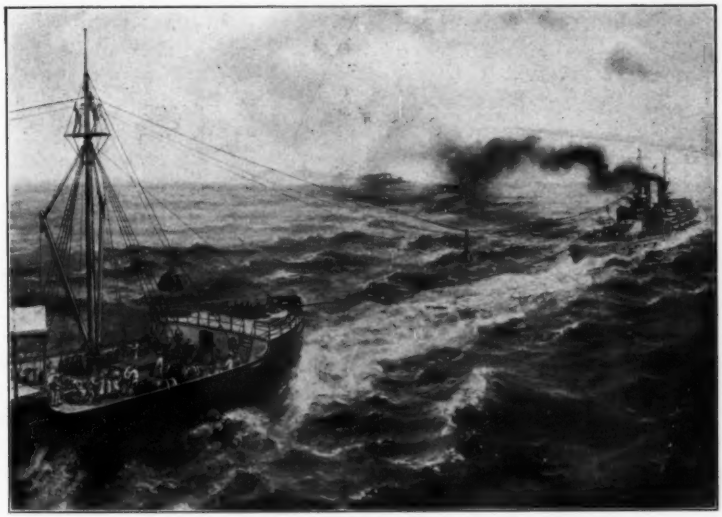
APPLICATIONS OF THE CABLEWAY TO ENGINEERING CONSTRUCTION.

The upper figure shows Temperley transporters applied to submarine work. The lower one shows a Lidgerwood cableway, 625 ft. span, 1½ yd. orange-peel bucket, 57 ft. traveling towers, at work on the Illinois & Mississippi Canal.

Cableways.—There are many locations where cableways furnish a convenient and economical method of handling materials. Notably has their use been successful in the construction of large dams, built of earthwork and masonry. Where the dam is built between high steep slopes, suitable anchorage for the main cable can be economically

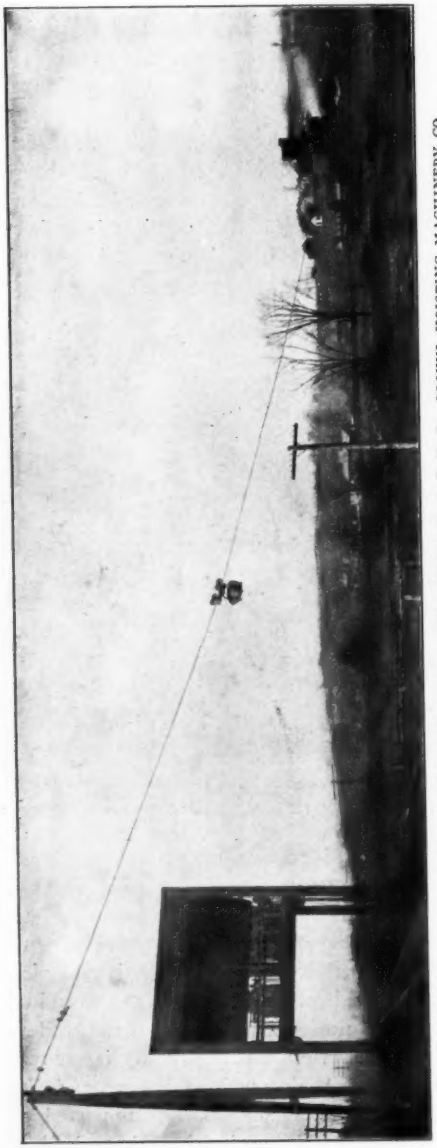
provided, and it is not necessary to build high and expensive towers to provide sufficient sag for the cable.

Spans of 1,200 or 1,500 feet are common. A span of 1,350 feet was used in the construction of the dam at Austin, Texas; and with it, loads of 7 or 8 tons were conveyed at a speed of 700 to 800 feet per minute. In spans of this length, some provision must be made for holding up the lines which are used for racking the trolley and hoisting the loads; otherwise the deflection of these ropes would be so great, as to cause trouble in lowering the empty hook or bucket, and possibly in lowering light loads. Many different devices have been used for supporting these ropes. One of the simplest and most ef-



WARSHIP TAKING COAL FROM A COLLIER BY THE MILLER-LIDGERWOOD MARINE CABLEWAY.

fective, perhaps, is that used by the Lidgerwood Company. An auxiliary rope, called the button rope, is suspended just above the main cable, and attached to this rope at various intervals are knobs or buttons. The sag carriers, which run over this rope, are provided with openings of various sizes. As the trolley travels along, it will pick up these sag carriers, one by one, and carry them along to the end of the run. There is a small horn or projection in front of the trolley, for picking up and supporting the carriers. When the trolley moves in the opposite direction, the carriers are dropped one by one, and distributed along the length of the rope, which is thus supported at proper intervals. From 400 to 500 cubic yards of earth or broken

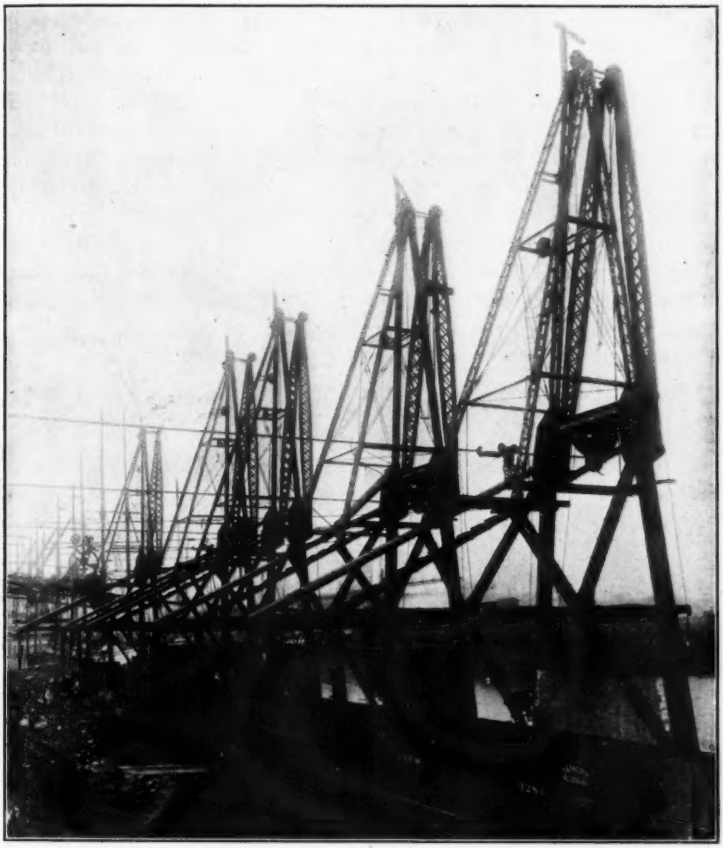


CABLEWAY AND LOCOMOTIVE FUELING PLANT, KING MINES, B. & O. R. R. BROWN HOISTING MACHINERY CO.

stone are handled in a shift of ten hours, by a machine equipped with a 75-horse-power boiler and 10 by 12-inch engine.

The picture on the left shows an interesting application of a cableway, as adapted to the fueling of locomotives with coal taken direct from the mine. The cableway is about 800 feet in length, and the buckets, which are loaded from a bin at the mine, are run out over the cable and dumped automatically into the bin over the railroad tracks. The coal is then drawn from this bin into buckets, where it is weighed and measured before being deposited in the tender of the engine. The buckets are counterweighted, so that as soon as the coal is dumped the buckets are lifted automatically into position, ready to be filled again. One man does all the work necessary for weighing the coal and loading the tenders, after the coal is deposited in the bin.

The lower picture on page 522 shows a cableway with movable piers



CABLE TRAMWAY FOR HANDLING ORE, N. Y. P. & O. DOCKS, CLEVELAND, OHIO.
With movable extension over the water. The Brown Hoisting Machinery Co., Cleveland, O.

or towers, as used in handling material from quarries, open-cut mines, in dredging canals, etc. The towers are placed on heavy trucks supported on wheels. Side rollers take the horizontal pull, and the towers are counterweighted, to prevent overturning. Back stays or permanent anchorages must, of course, be dispensed with where the towers are movable. The moving gear of the tower which carries the engine is coupled directly to the engine. The moving gear for the opposite tower is operated by moving the trolley back and forth along the cableway, suitable provision being made for attaching this mechanism to the racking ropes at the trolley.

Where cableways are used for handling material on docks, as in loading and unloading boats, the projection over the water must be so made that it can be raised up out of the way of the masts and rigging of the boat when the cable is not in use. Page 525 shows such an arrangement. The length of the cable is kept nearly constant with the projection (called an apron), either in the up or down position, guide sheaves and rollers being used to keep both the main cable and the racking and hoist lines in their proper relative positions.

In one type of cableway, only one line is used for supporting the load, raising and lowering it, and also for racking the trolley. Mr. Charles Hodgson took out patents on such an arrangement in 1868. Mr. Alexander E. Brown also has such a device.

AUTOMATIC ROPEWAY, KITTIE BURTON GOLD MINE, ULYSSES, LEMHI CO., IDAHO.

3200 ft. long, with a fall of 824 ft.; capacity 10 tons of ore per hour. The 1250-ft. span shown is the lower end. A. Leschen & Sons Rope Co., St. Louis.

Aerial Tramways.—Aerial tramways are merely a modified form of cableway. The principal differences are:—

First.—Cableways usually have only one main suspension cable; Aerial tramways have two. That is, the loaded buckets are carried on one cable, and returned empty on another; curves of sufficient radius being provided to allow the trolleys carrying the buckets to pass from one cable to the other at the end of the run.

Second.—Cableways consist of only one span, whereas the aerial tramway consists of a succession of short spans, say 300 or 400 feet in length. The total length of the cable may be several miles, and it is often carried down one hill-side, along a valley, and then, perhaps, up

AUTOMATIC TRAMWAY, NORTH AMERICAN COPPER CO., ENCAMPMENT, WYO.

16 miles long; capacity 40 tons an hour. Operated in three sections, one of 8 miles and two of 4 miles. A. Leschen & Sons Rope Co., St. Louis.

over a second hill. The supports at the top of the towers for carrying the cable, and the trolleys supporting the buckets, are so designed that the trolleys pass by these supports without interference.

Third.—The cableways usually have only one trolley carrying one load. Aerial tramways have a succession of small buckets attached to trolleys, which are spaced at regular intervals along the entire length of the main cable. The buckets are usually of much smaller capacity than used on cableways, loads of from 500 to 1,000 pounds being perhaps about the average.

Aerial tramways are extensively used in mining and lumber regions, where steep slopes and irregular ground would render almost any type of conveying machine impossible. An example of this specialized service is shown in the marine cableway on page 523.

Industrial Railways.—Cars of small capacity, and made automatic or self-dumping, are extensively used in large manufacturing concerns for conveying coal, ashes, coke, and all kinds of material from point to point about the works. They are also extensively used in the construction of large excavations, and fills for railways, etc. The C. W. Hunt Company, of New York, are one of the largest manufacturers of this type of conveying machinery. The cars may run either upon the ground, or upon elevated trestles, or may even be suspended from overhead runways, in which case they would probably be operated by small electric locomotives of the suspended type. Compressed air has also been used to a considerable extent for this purpose. Such railways and their equipment are illustrated in the articles by Messrs. Waldron and Porter, elsewhere in this number.

Belt and Bucket Conveyors.—Various types of belts and endless

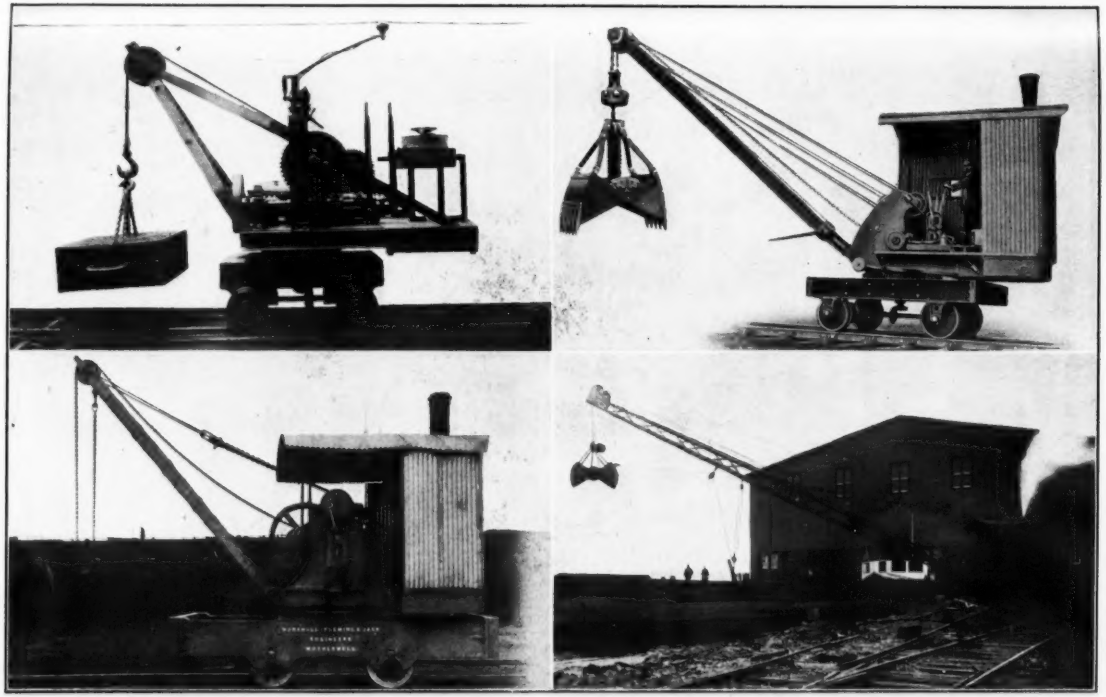
RIDGWAY BELT CONVEYOR, HANDLING SAND, STONE AND GRAVEL FOR A CONCRETE-MIXING PLANT.

20-in. belt, 350-ft. speed; capacity 125 yds. an hour. Ridgway Belt Conveyor Co., N. Y.

chains, to which small buckets are attached at frequent intervals, are used for carrying the output of mines and excavations up steep inclines, for distances of several hundred feet.

If a belt conveyor is used, the material will be dumped on to the belt through chutes, and the conveyor then carries it in an endless stream up the incline and deposits it at the top. The bucket conveyor takes up the material from a pit or trough, and as the buckets pass over the upper supports, they all, of course, turn over and empty themselves. Belt conveyors are shown in the illustrations on this page and page 531. A belt conveyor 32 inches wide will convey from 25 to 30 tons of ore per hour, the speed of the belt being from 30 to 60 feet per minute. Crushed stone has been carried on 16-inch conveyors at the rate of 200 cubic yards per hour. Thirty-six inch belts have been used in connection with dredges and have carried material, including broken stone, at the rate of 1,200 tons per hour a distance of 70 feet, the belt speed being 550 feet per minute. The maximum angle at which belt conveyors will work satisfactorily is about 25° with the horizontal.

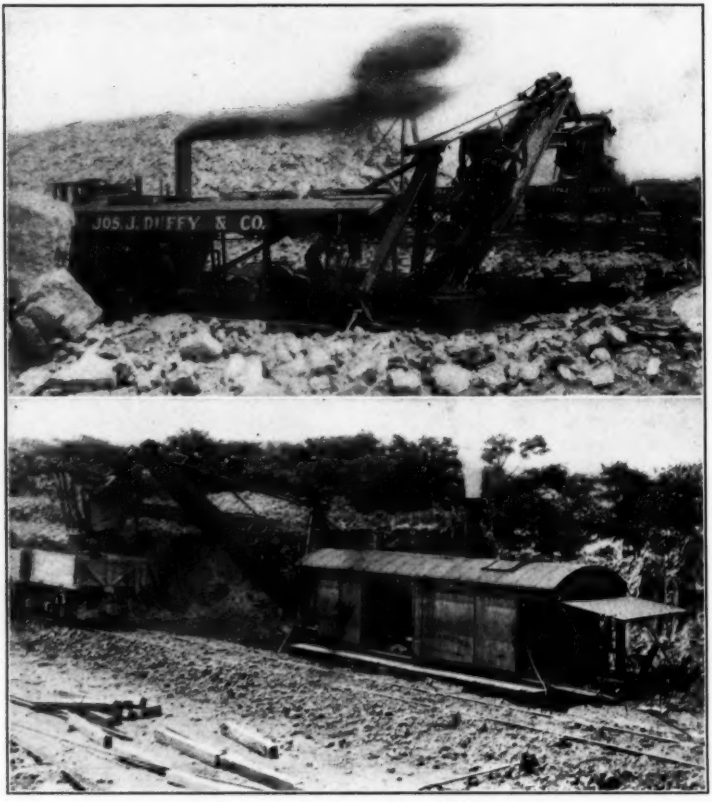
Locomotive Cranes.—The use of small locomotive cranes of 5 to 10 tons capacity, for handling coal, coke, ore, etc., and for excavating ditches and canals of moderate depth and width, has been very greatly increased during the last few years. This is due largely to the fact that grab buckets suitable for handling these materials have recently been placed on the market. Only one man is required to operate these cranes, and from 50 to 150 tons per hour are easily handled with them. Gondola cars can be rapidly unloaded, and the entire contents of the car taken out without the aid of hand shoveling. An illustration in Mr. Hatch's article, page 591, of this number, shows



EXAMPLES OF LOCOMOTIVE CRANES FOR CONTRACTORS' AND SIMILAR USE.

On the left, above, a 3-ton portable electrically driven crane by Jessop & Appleby Brothers, Ltd., Leicester; to the right of that, a steam crane and grab by the same makers; on the left, below, a steam crane, contractors' class, made in sizes from 3 to 10 tons, with radius from 14 to 12 ft., by Marshall, Fleming & Jack, Motherwell; in the lower right corner, a 10-ton locomotive crane with 60-ft. boom, built by the Browning Engineering Co., Cleveland, O., for the Hudson Cement Co.

a locomotive crane unloading ore from cars, and depositing it in a stock yard, and other types are shown opposite. These cranes, being light, do not require the heavy foundations for carrying them which would be necessary for steam shovels. They are, of course, self-propelling, and can be made to handle their own tracks, picking up the sections which have been left behind the crane and placing them in position in front, only two or three short sections of track being required as the crane moves along from position to position. If the material conveyed can be deposited in piles along the sides of the cut, the locomotive crane does this work with only one handling of the material. These cranes have been built with booms of from 50 to 60



TYPICAL AMERICAN STEAM SHOVELS.

Above, a shovel built by the Vulcan Iron Works, Toledo, Ohio, working on the new power canal of the Chicago Sanitary District; below, a shovel by the Marion Steam Shovel Co., Marion, Ohio, working on the line of the Pennsylvania Railway.

feet in length, and it will thus be seen that a canal of considerable width could be excavated by them without moving the crane sideways. One important feature in their favor is the fact that only one man is required for operating the crane and handling the material.

REFUSE CONVEYOR, RIKER'S ISLAND PLANT, N. Y.

The total length of conveyor is 1,000 ft., and of the belt about 2,000 ft.; discharge is made at any point by the movable tripper provided with an auxiliary conveyor, as shown. For general conveying, 10-in. to 36-in. belts are used, running 200 to 700 ft. a minute and handling 15 to 1500 tons an hour, according to kind of material and size and speed of conveyor. For picking or sorting ore, the Robins belt is made wide and flat-troughed and run at 30 to 50 ft. a minute. A 32-in. belt will handle 25 to 50 tons an hour.

Robins Conveying Belt Co.

Steam Shovels.—Up to the present time, no machine has been so extensively used for handling material from large railway cuts, in building embankments, and in moving the material from open-cut mines, as some type of steam shovel. (See pages 530 and 532).

Open-cut mines in the Lake Superior region are almost entirely worked thus. In excavating the Chicago Canal, a 60-ton machine handled about 600 cubic yards of hard cemented gravel in a day of 10 hours; 70-ton machines excavated about 700 yards. In stripping gravel drift at the Mesaba iron mines, a 65-ton machine, equipped with a 2½-cubic-yard shovel, has handled about 2,000 yards a day. The contract price paid for handling this material varies from 20 to 50 cents per cubic yard. In loading the ore itself, a 65-ton shovel will load from 70 to 80 cars of 25-tons capacity in 10 hours. A 70-ton shovel with a 2½-yard dipper, has handled ore in the Michigan fields at 2.53 cents per ton. Much heavier shovels are now being introduced, some weighing 100 tons or more.

TYPICAL AMERICAN STEAM SHOVELS.

At the top, a shovel built by the Bucyrus Company, South Milwaukee, Wis., working in the excavation for the new Pennsylvania Railroad terminal in New York City. Below, a new type of shovel, designed by Mr. A. W. Robinson and built by the American Locomotive Co., at work on a railroad cut.

The Bucyrus Company have over one hundred steam shovels in use on the iron ranges of Minnesota, Wisconsin, and Michigan. They use two classes of shovels. Shovels of 65 and 70-tons weight are used for stripping off the material over the ore, and 85 and 90-ton machines (the latter having a dipper of 5-cubic-yards capacity) are used for handling the ore itself. These machines are very heavily and substantially constructed throughout. There are three engines—the main engine operating the hoisting and propelling machinery, a smaller engine for swinging the boom and dipper, and a third engine for thrusting the dipper handle. Page 532, upper figure.

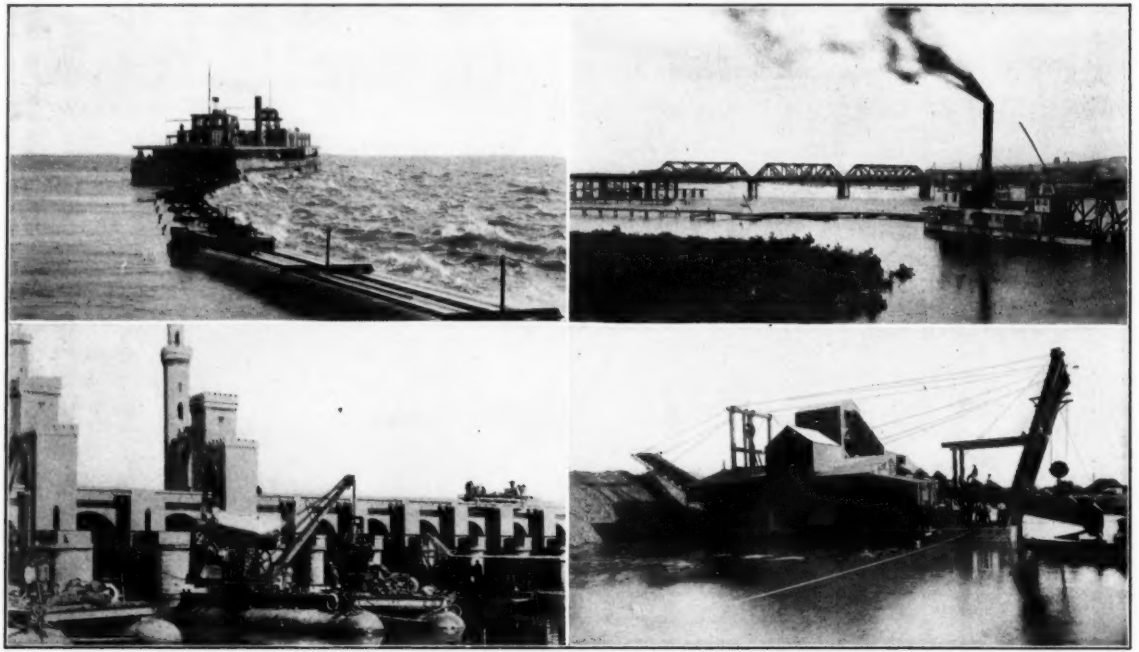
This company has a contract for thirteen shovels of 70 and 95-tons weight, to be used on the Panama Canal. The makers claim a capacity of 3,000 to 4,000 yards per day of 10 hours, and state that the 95-ton shovels have a record of handling material at the rate of 8,180 yards per day of 10 hours, including all stops.

The Vulcan Iron Works, of Toledo, Ohio, have five of their shovels at work on the construction of the power canal of the Chicago Sanitary District. This canal, running between Joliet and Lockport, Ill., is designed to furnish power for the city of Chicago. There will be excavated about 4,275,000 cubic yards of rock, and 105,000 cubic yards of earth. Some of the material handled requires machines of large power and of the strongest construction. The upper figure on page 530 shows one of these machines.

For stripping the coal fields in Kansas, a combination of shovel and belt conveyor is used. The shovel deposits its load in a belt made of heavy canvas which conveys the materials out to a distance of about 75 feet and dumps it. A shovel of one cubic yard capacity handled about 1,200 cubic yards in 10 hours. The belt has a speed of about 120 feet per minute, and a 50-horse-power boiler is used to operate both the shovel and the belt conveyor.

Dredges.—There are three prominent types of dredges; the dipper, the elevator or bucket type, and the hydraulic or suction dredge. The first is very similar to the steam shovel in design and operation. It is mounted upon a pontoon, instead of being mounted on wheels and running on tracks. This type seems to be a favorite for harbor and river work in the United States.

In Europe the elevator and hydraulic types seem to be preferred. Some of the larger dipper dredges have a dipper or bucket with a capacity of 4½ to 5 cubic yards. The quantity of material which can be handled per day varies from 500 to 1,500 cubic yards or more This, of course, depends entirely upon the capacity of the dipper, the character of the material, and the ability of the operating workmen.



TYPES OF DREDGES, OF VARIOUS CLASSES, IN ACTUAL OPERATION.

The dredge shown in the top left-hand quarter is the J. Israel Tarte, 160 x 42 x 12 ft., 1500 h.p., dredging in the St. Lawrence to a depth of 35 ft. and delivering through 2,300 ft. of pipe at the rate of 2,000 yds. blue clay per hour; built at the Polson Iron Works, Toronto, from designs by A. W. Robinson. To the right, above, is a hydraulic dredge of the Atlantic, Gulf & Pacific Co., N. Y., working at Albany N. Y. Below, on the left, are Kingston dredgers of the barge type, on wire pontoons, employed on the reconstruction of the lower barrage on the Nile. In the lower right corner is a bucket dredge working in gold ore.

For gold dredging in the Western States, the elevator or endless chain type is the favorite. These dredges excavate the gravel, screen and wash it, separate the gold, and then deposit the refuse or tailings. The buckets weigh about 1,000 pounds each, and the total weight of the machinery, on a dredge of this character, may be 500,000 pounds or more. The capacity of these dredges is from 50,000 to 75,000 cubic yards per month, or 2,800 cubic yards per day as a maximum. A 50,000-yard dredge would have engines of about 160 horse-power, and a 75,000-yard dredge would have engines of about 230 horse-power. The cost of handling material with these machines is from 5 to 7 cents per cubic yard. Page 534 shows one of these dredges in operation, and also several of other types.

One of these is one of the hydraulic dredges of the Atlantic, Gulf and Pacific Company, working at Albany, New York. These machines operate by swinging radially about a center spud, and are moved forward by using two spuds as alternate centers; a rotary excavator with a suction pipe opening within it is always present, but there are several methods of operating, depending on the character of material handled.

This company owns and operates dredges of 18, 20, 22, 24, and 30-inch sizes. The output, of course, varies according to the material handled, and the conditions under which the machine is working. Twenty-nine thousand cubic yards have been handled in one double-shift day, with a twenty-four inch machine. One machine has discharged material through 12,000 feet of pipe line. The machines owned by this company have handled approximately 60,000,000 cubic yards of material.

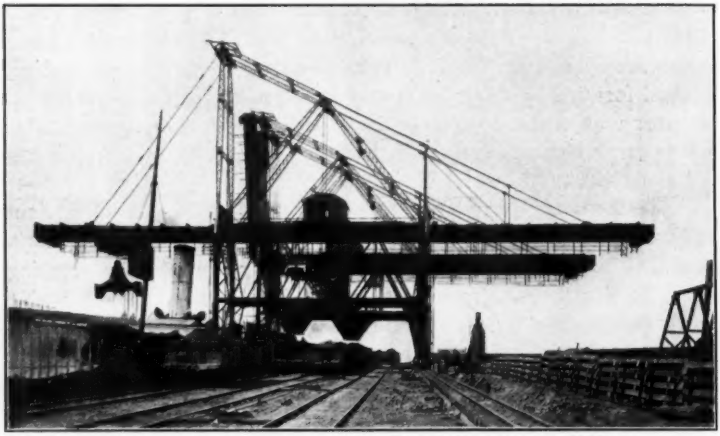
An elevator dredge at Cologne, Germany, has double bucket chains, and the capacity of the machine is about 260 cubic yards per hour. The capacity of the buckets themselves is about 35 gallons. Two engines of 250 horse-power are used.

At the North Baltic Canal, a bucket dredge with force pumps was used, which forced the material about 900 feet and elevated it about 6 feet, at the rate of about 260 cubic yards per hour. The engines were 175 horse-power.

Cranes.—Cantilever and gantry cranes of numerous types have been used extensively in the handling of materials at mines, ore docks, etc., and in the construction of canals and excavations. In building the Chicago Drainage Canal, one of the most successful machines used was a cantilever crane, having a trolley travel of 343 feet and a capacity on the hook of 5 tons, which is equivalent to a 2½ to 3-cubic-yard bucket loaded with stone. These cranes were built by

the Brown Hoisting Machinery Company, of Cleveland. (See page 537). The engines used were 10½ by 12 inches. Eleven of these machines were used, and the average amount handled by each machine was about 540 cubic yards per day. The cost per day of operating one machine was $9.75, as follows:—

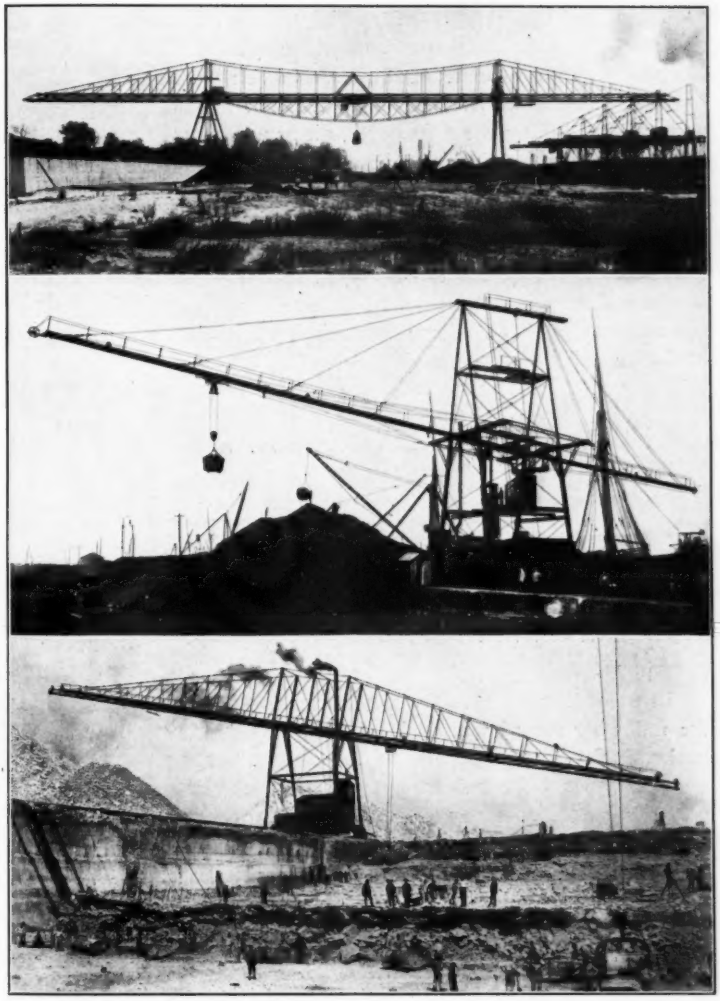
Engineer	$2.25
Oiler	1.75
Operator	2.75
Coal used	2.75
Water, oil, waste, etc	25
Total	$9.75



5-TON UNLOADERS, DOCK OF THE PITTSBURG & CONNEAUT DOCK CO., CONNEAUT, OHIO.
The Brown Hoisting Machinery Co.

The cost per yard for handling material would be from 2½ to 3 cents. If these cranes were used for similar work today, much greater quantities could be handled, particularly if grab buckets were used for picking up such material as could be handled by them, and the cost per yard of material handled would not exceed 2 cents.

If the grab buckets were used, the number of men required to operate the machines would be very much less, and of course, the cost of the material handled would also be greatly reduced. This type of crane is extensively used in ship yards and similar places. There is little doubt that they would prove very efficient and economical in stripping ore mines, and in handling the ore itself in such locations as the mines in the Lake Superior region. It is a little surprising that they have never been used at these mines.



TRAVELING GANTRY AND CANTILEVER CRANES FOR HANDLING MATERIALS.

At the top is the plant of the Conneaut Dock Co., Conneaut, Ohio; next below is a traveling transporter for handling coal, iron ore, etc., supplied by the Temperley Transporter Co., London, to the Sociedad Viscaya, Bilbao. It lifts a gross load of 35 cwt. at a speed of 250 ft. a minute and transports it along the beam at 600 to 800 ft., handling over 60 tons an hour. At the bottom is a cantilever crane, digging the Chicago Drainage Canal; built by the Brown Hoisting Machinery Co.

There are many types of moving cantilever cranes. One of the most remarkable, perhaps, of these plants, is the Conneaut Dock equipment, at Conneaut Harbor, Ohio, shown on page 536. The buckets of the unloaders, although designed to take 5 tons of ore, will, when handling the softer ores, pick up 7 or 7½ tons.

The trolleys for the unloaders are placed on turntables, so that the bucket can be revolved after it has been lowered through the hatch, so as to reach the ore between the hatches. In a suitable boat the ore can be entirely removed without the aid of hand shovelers.

The large bridge crane is equipped with a 7½-ton bucket, and is used for storing such portions of the ore as are not required for direct shipment by cars. Some data relating to these cranes, are given in the list below:—

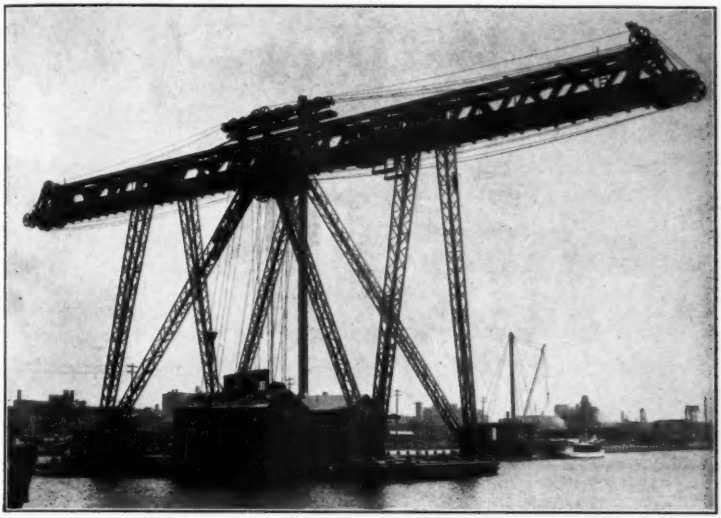
	Fast Plant. Pounds.	Bridge Tramway. Pounds.
Capacity of hook	20,000	28,000
Capacity of bucket	10,000	14,000
Total weight of crane	337,000	1,039,000
Total weight of trolley and bucket	59,400	69,000
	Fast Plant. Feet per minute.	Bridge Tramway. Feet per minute.
Speed of hoist	300	225
Speed of trolley travel	1,000	1,000
Speed of bridge travel	75	75

	Motors. Fast Plant.	Bridge Tramway.
Hoist	Two of 150 h. p.	Two of 150 h. p.
Trolley travel	One of 100 h. p.	Two of 75 h. p.
Bridge travel	One of 75 h. p.	One of 150 h. p.

In unloading the steamer Cornell, October 17th and 18th, 1904, the following record was made:—Total tons, 5,970; total number of buckets, 104; average per bucket for the first car, 7.7 net tons; average per bucket for eleven cars, 5.74 net tons; average per bucket for 77.7 per cent. of the cargo, 4.5 tons; tons per hour, 180. The cost per ton for handling did not exceed 7/10 of a cent.

Pontoon Cranes.—There are a great variety of pontoon cranes used on construction work in rivers and harbors, at government fortifications, etc. One of the largest and most interesting of this type of cranes is the 100-ton balanced crane recently built by the Brown Hoisting Machinery Company, for the New York Navy Yard. This crane has a trolley travel of about 190 feet. Loads can be hoisted 65 feet above the mean draught of the pontoon, and lowered to a depth of about 20 feet below this line. Two locomotive boilers of 80 horsepower are used for furnishing steam at 100-pounds pressure. The main engine is of the double cylinder horizontal type, with 12-inch by 15-inch cylinders.

Running on tracks, in the hold of the pontoon, there is a large



100-TON PONTOON CRANE AT THE NEW YORK NAVY YARD.
Built by The Brown Hoisting Machinery Co.

counterweight operated by a double-cylinder 7-inch by 9-inch engine, so arranged that whenever the pontoon tips, on account of a load being raised by the crane, the counterweight is immediately and automatically started in the opposite direction, and moved until the boat is brought to an even keel again, when its motion is automatically stopped. Six water-tight compartments are also provided, which can be used as desired in trimming deck loads. The crane will carry, in addition to the 100 tons carried at the end of the runway, a load of 300 gross tons on the deck. This crane is used for handling armor plate, guns, and other bulky material. It is shown above.

In order to determine what type of apparatus is best adapted to any particular undertaking, it is necessary to understand fully all the conditions under which the machinery must be operated. The character of the materials to be handled, and even the class of men who will be employed to operate the mechanism, must all be considered. Failure to understand fully all the items which would affect the working of a plant has been the cause of failure in much conveying machinery. It is not at all certain that a machine which has done excellent work under certain favorable conditions, will not be a failure if some of these conditions are even slightly changed.

A dipper dredge may be best adapted for handling hard material in harbor and river excavations, where the material is dumped into

A SEWER MACHINE.

It is essentially a movable overhead tramway, consisting of a track beam supported on A frames. On the tracks run carriers, to which are attached buckets for the material to be excavated and moved. Hoisting, lowering and traveling movement requires co-operation of the attendant at the excavation and the engineer in the engine house. Accidents are thus avoided. Maximum speed 800 ft. a minute. The Brown Hoisting Machinery Co.

scows. For handling light, loose material, where the conditions are favorable for discharging through long pipes, at a low cost, the hydraulic dredge may be better. For the peculiar conditions encountered in gold dredging, in certain parts of the Western States, the elevator or bucket type has been the favorite, as has been stated above.

In canal work, if the material has to be carried back long distances to be dumped, a cableway or some form of belt or bucket conveyor may be well adapted. If the distance over which the material is carried is only one hundred or two hundred feet, then a cantilever crane would be a very satisfactory machine, particularly if the material is such that it can be handled by grab buckets.

For loading directly on cars where the ground is solid enough to support heavy steam shovels, machinery of this type would, perhaps, give the best results.

For transferring material down rough mountain sides, over rivers, and across ravines, some form of cableway naturally suggests itself. There are many locations where a gantry traveling crane would be well adapted to perform rapid and economical work. The limited space allowed for this article permits the description of only a few of the most common type of machines. There are many other types which are, perhaps, equally worthy of mention, but which have of necessity been omitted.

THE MECHANICAL TRANSPORT OF AIR.

By Walter B. Snow.

BELLOWS APPLIED TO MINE VENTILATION.
Agricola, "De Re Metallica," 1556.

WHOLESALE transportation of fluids is rarely accomplished by actual carrying, but almost universally by the process of flowing, which the derivation of the word fluid naturally suggests. As the river flows toward a lower level because of the lesser resistance, so air in atmospheric areas of high density rushes toward those of lower density, with resulting air movement or transportation upon a stupendous scale. But while in the case of water a pressure difference measured by a single inch of head creates but sluggish movement, the same intensity of pressure in the mobile air produces a velocity of about 45 miles per hour. For the economical movement of air in conduits this velocity, equivalent to nearly 4,000 feet per minute, is seldom exceeded. In fact, improved efficiency is to be sought by its reduction to the point where the decreased friction losses are offset by the increased cost of the conduit necessary to convey the desired volume at the lower velocity.

In the case of a gas, or a mixture of gases like air, it is manifestly the province of any system of transportation so to increase the pressure at one end of a conduit, or to decrease it at the other, as to establish a difference sufficient to create the required rate of flow. The theoretical velocity is determinable by the well known formula:—

$$V = \sqrt{2gh}$$

in which V is the velocity in feet per second; h is the head in feet or the pressure divided by the density; and g is the acceleration due to

ROTARY BLOWER APPLIED TO MINE VENTILATION.
Agricola, "De Re Metallica," 1556.

gravity, namely, 32.16. In practice the discharge orifice and the conduit restrict the freedom of flow, and a portion of the pressure, denominated the *pressure head,* is expended in overcoming this resistance; while only the balance of pressure known as the *velocity head* remains available for actual air movement.

For a given velocity the total frictional resistance to the movement of air in a pipe is proportional to its surface, or in the case of a round pipe to its diameter, while the pressure head per unit of area necessary to overcome this resistance varies as the ratio of the surface to the area, that is, inversely as the diameter. For illustration:—the total frictional loss in a 100-inch pipe will be ten times that in a 10-inch pipe, while the required unit pressure head will be only one-tenth as much in the former as in the latter. The power expended to overcome resistance is manifestly proportional to the total loss, and is measured by the product of the area into the pressure head per unit of that area. This power being utilized solely to create pressure head is of no direct avail in the actual movement of the air, for which additional pressure or velocity head must be provided. The sum of the pressure head and the velocity head obviously represents the total pressure difference which it is the province of any system to create.

The simplest of all methods of creating such a difference is by heating the air within a vertical conduit (of which the chimney is a familiar illustration) thereby reducing its density and inducing at the bottom an inflow of the cold and heavier outside air. Because of its simplicity, it was but natural that this method should have preceded

the application of mechanical devices for artificial ventilation. But simplicity and efficiency do not here go hand in hand.

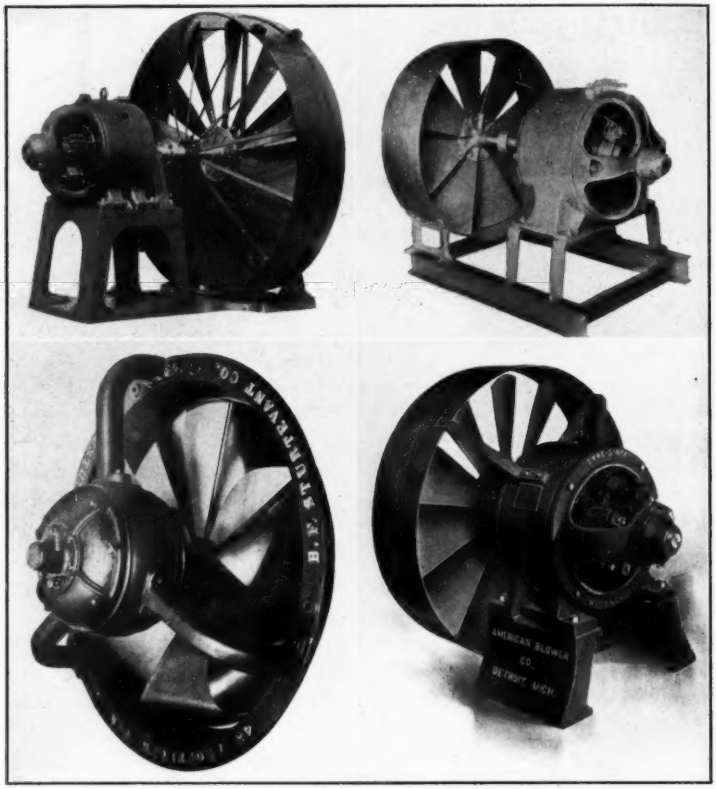
The bellows appears to have been the first mechanical contrivance utilized for the purpose of ventilation. The date of its invention is, however, buried in the dim past, although as early as 1556, Agricola in his elaborately illustrated work, *De Re Metallica,* shows this simple device, as well as a crude form of rotary blower applied for the ventilation of mines. The fan or centrifugal blower has, however, long been accepted as the only effective mechanism for creating wholesale air movement.

The air compressor, producing pressures up to 100 pounds or over, the blowing engine operating within the usual range of 10 to 20 pounds per square inch, and the positive or rotary blower seldom exceeding 5 pounds in the pressure created, are not primarily designed for mere movement of air, but more essentially for the creation of pressure and transmission of the same through the medium of the air. The propeller or disc fan, on the other hand, is efficient only under very low resistances and is incapable of economically forcing the air through conduits of very great length.

The maximum economical working pressure for the fan blower is well established at about one pound per square inch, but for the purposes of ventilation its rotative speed seldom exceeds that necessary to create a pressure of one ounce per square inch and a correspondingly velocity of somewhat over 5,000 feet per minute which, in general practice, is reduced to about 3,500 feet in the conduits, corresponding to about one-inch head of water.

The province of a fan wheel when in motion is to create such a pressure difference between the inner and outer diameters of the blades or floats as to cause a flow of air from the center to the circumference. The resulting action is well exemplified by rotating a tube about an axis established at right angles to its own and midway of its length. By centrifugal force the air is thrown outward from its open ends, and a partial vacuum created at the axis about which revolution occurs. If an opening be made at this axis, air will rush in to supply the vacuum and a constant flow will be established.

Much thought has been expended upon fan design, with many resulting arrangements of the fan blades and casings. Some blades are radial, some curved forward, and some backward, while others combine these forms; some fans are relatively wide and of small diameter, others of almost excessive diameter, but of minimum width; some run free in the atmosphere, while others are equipped with casings of varied design. In all these forms the effort has ever



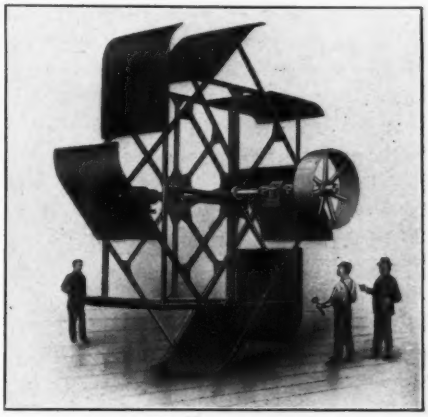
FOUR TYPES OF ELECTRIC-DRIVEN VENTILATING FAN UNITS.

In the left upper corner, direct-connected fan by S. B. Stine & Son, Osceola Mills, Pa., to the right of it, 4-ft. fan for auxiliary mine ventilation, 30,000 cu. ft. of air per minute, 10 h.p. motor, made by the General Electric Co.; in the lower left corner, electric propeller fan of the B. F. Sturtevant Co., to operate at 300 revolutions, create .85 in water pressure, and deliver 11,000 cu. ft. of air; lower right corner, disc fan wheel with direct-connected Westinghouse motor, American Blower Co.

been to improve the efficiency; but frequently greater volume or pressure has been secured only by increased expenditure of power. In fact, the simpler still remains not far behind the more elaborate in economy of operation.

The effect of high velocities is clearly shown by the fan, in which doubling the rotative speed simply doubles the volume discharged, while producing four times the pressure and requiring eight times the power. That is to say, the volume varies directly as the number of revolutions; the pressure varies as the square, and the power

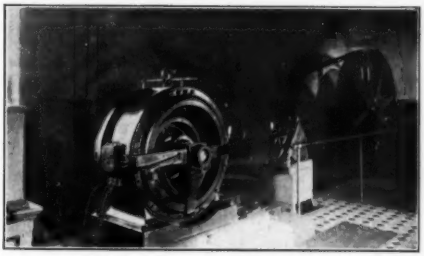
required as the cube of the revolutions. It is therefore evident that a fan which is only half large enough to move the desired volume at the required pressure will have to be run at double the speed, and will absorb eight times the power necessary to operate a fan of proper proportions. In a word, a fan should be so proportioned to its work as to make possible the delivery of the necessary quantity without exceeding the minimum permissible pressure.



MINE FAN, GUIBAL TYPE.
Made in sizes 14-ft. diameter and upward. American Blower Co.

In no line of industry requiring air movement upon a large scale has the efficiency of its movement received more careful study than in the case of the modern mine, with its miles of underground workings located thousands of feet beneath the surface. Here ventilation is imperative if human labor is to be continued. That the volumes handled are necessarily large is evidenced by the estimate that the weight of air passing through the coal mines of the United Kingdom is approximately twenty times that of the coal taken out.

Whether a fan shall be installed to force the air into the mine under the plenum system, or to exhaust it under the vacuum system, is dependent upon the character of the mine, frequently modified to large degree by the personal preferences of the manager; for the superiority of neither system is finally established. The very general application of the latter system throughout the United States is, however, fair evidence that it best meets the requirements in the average mine.



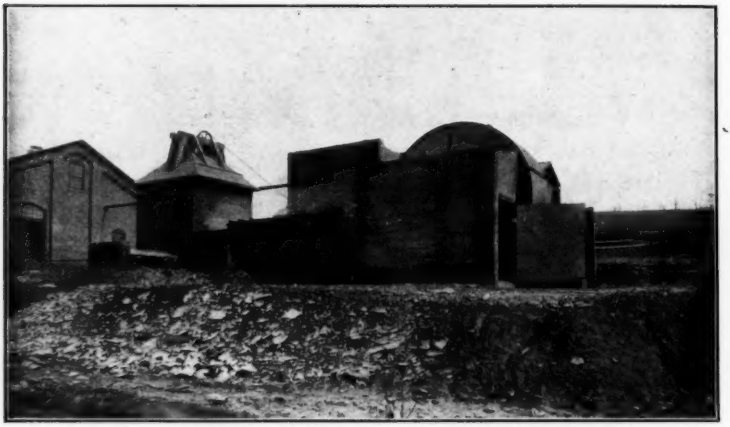
MINE VENTILATING FAN, KOENIGIN LOUISE COLLIERY, ZABORZE.

75 h.p., three-phase motor. Allgemeine Elektricitäts Gesellschaft.

Mine-ventilating fans operating upon the exhaust principle may be classed into three leading types.

1.—The open running, in which the fan wheel is devoid of casing and delivers the air freely around the entire circumference.

2.—The close cased fan with expanding chimney, which permits of the gradual reduction of velocity and pressure of the air delivered, thereby reducing resistances and increasing efficiency.

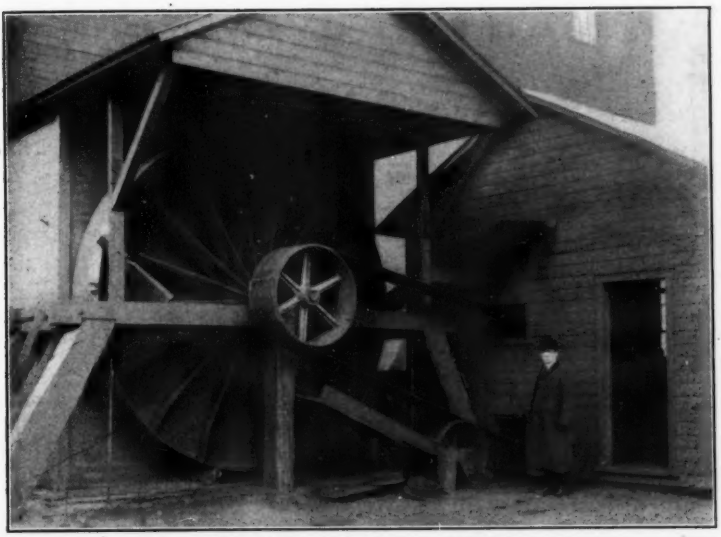


REVERSIBLE MINE VENTILATING FAN, 20-FOOT WHEEL, 9-FOOT FACE.
Edna No. 2 mine, United Coal Co., Irwin, Pa. Installed by Robinson Machine Co., Monongahela, Pa.

3.—The spiral cased fan with expanding chimney. The involute form of the casing provides a constantly increasing space for movement of the air after leaving the tips of the wheel blades and permits of free discharge with minimum resistance through the special form of outlet.

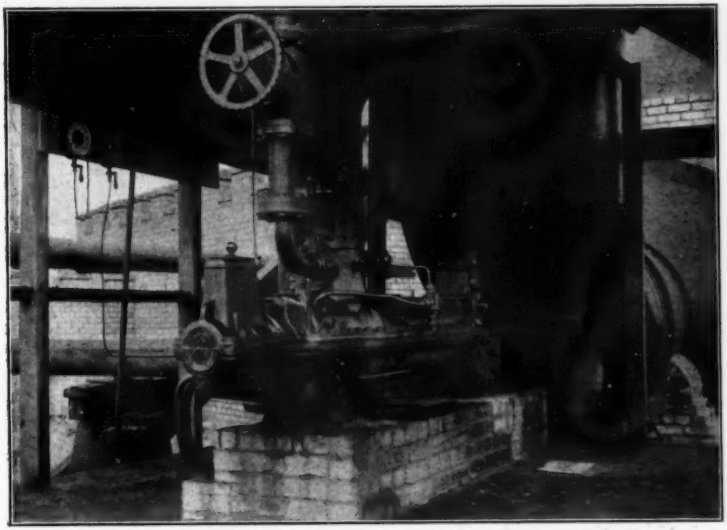
The form of the case and the design of the outlet have a large influence upon the efficiency. In English practice there has been a tendency to cling to the second type, in which the efficiency seldom exceeds 60 per cent., while in America the third type has been generally installed with efficiencies sometimes running up to 70 and 80 per cent. Peripheral velocities usually average between 5,000 and 6,000 feet per minute, the rotative speed depending, of course, upon the fan diameter, which, in English practice, runs up to 35 or 40 feet.

The railroad tunnel, with its volumes of locomotive smoke and its high temperature, presents a most difficult problem in air transportation and ventilation. Its successful solution is to be credited to the Italian engineer, Saccardo, who first applied his method in



MINE FAN, MORRISDALE COAL CO., MORRISDALE, PA.

12-ft. diameter, capacity 75,000 to 100,000 cu. ft. per minute. One of four installed by S. B. Stine & Co., Osceola Mills, Pa.

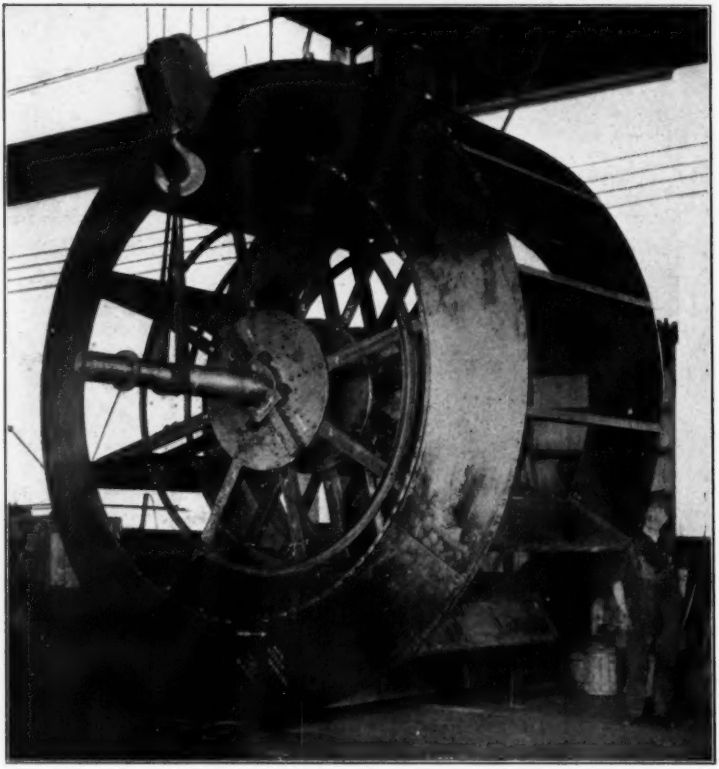


TURBO-FAN, CLARA VALE COLLIERY, WYLAM-ON-TYNE, ENGLAND.

5-ft. diameter; capable of passing 100,000 cu. ft. of air per minute at 2-in. water gauge. C. A. Parsons & Co., Newcastle-on-Tyne.

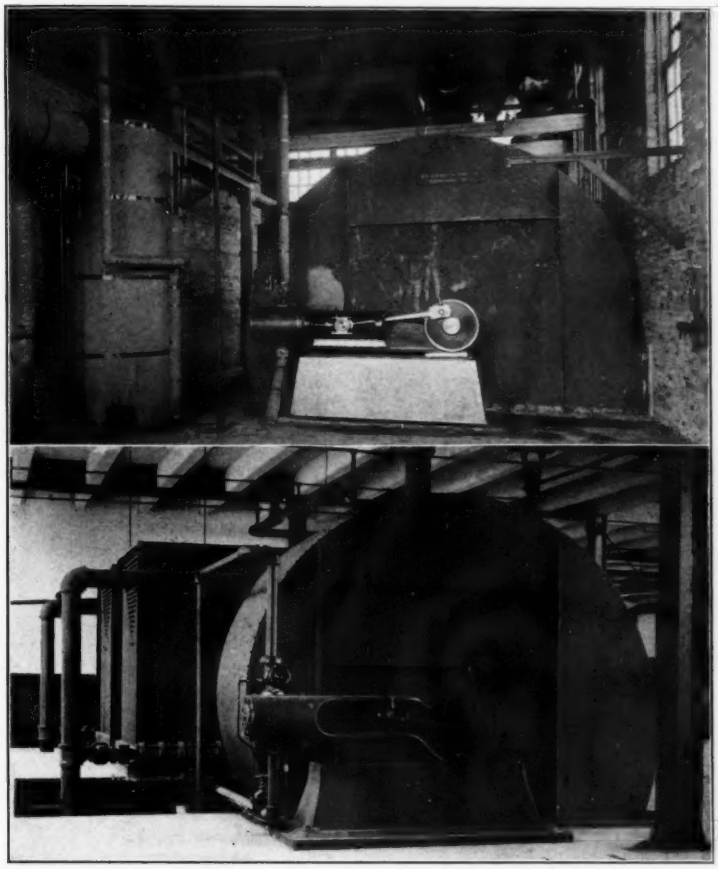
the construction of the Pracchia tunnel. Similar applications have since been made in the United States with marked success. In this system the air is forced into an annular space arranged around one entrance and thence discharged longitudinally into the tunnel. Acting upon the injector principle, it induces an inward flow of the outer air through the regular tunnel entrance. The fan blower is absolutely necessary to secure these results, although only a portion of the air actually passes through the fan. The rate of flow is so regulated as to exceed that of regular trains passing through the tunnel, with the surprising result that the smoke is blown ahead of the locomotive, leaving the train in a clear and fresh atmosphere.

In all systems of ventilation the air plays a two-fold part. It not only meets the needs of respiration, but in the process of movement



A 16-FOOT TUNNEL VENTILATING FAN.

To operate at 140 revolutions, 3.25 in. water pressure, and deliver 250,000 cu. ft. of air per minute under working conditions. B. F. Sturtevant Co., Hyde Park, Mass.



MECHANICAL HEATING AND VENTILATING INSTALLATIONS.

The upper one was installed for the National Electric Co., Milwaukee, by Wm. Bayley & Sons Co., Milwaukee. 12-ft. fan, 82,000 cu. ft. air per minute at 100 revolutions; heats shop 200-ft. square and 3 stories high, 400-ft. away, the air being carried through galvanized-iron ducts and tunnel. The lower installation is the B. F. Sturtevant Co.; two 10-ft. wheels driven by 9 by 12 horizontal engines; 20,000 lineal ft. of pipe in heater; delivers 150,000 cu. ft. of air per minute and heats 3,000,000 cu. ft. of space.

serves as the medium by which impurities are removed or heat is transmitted. The modern system of mechanical ventilation and heating depends for its success upon this dual property. The fan serves to supply air in quantity to meet the requirements of ventilation, while a primary heater established in connection with the fan transfers to the air sufficient heat to make good the losses by radia-

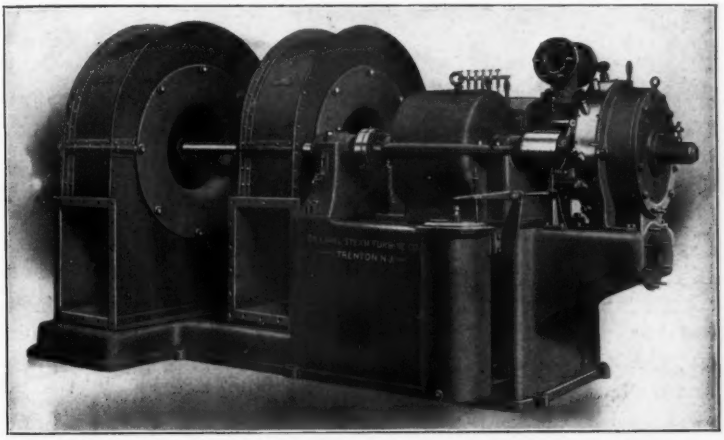
tion, conduction, and direct escape of air from the apartment to which it is delivered. The more rapid the air change the less the temperature increment required.

A supply of 30 cubic feet per minute per individual is essential to even fair ventilation, while 50 cubic feet is necessary to produce a feeling of freshness in the atmosphere of an occupied room. The difficulties in the way of securing imperceptible ventilation are measured directly by the frequency with which the air must be changed within an apartment. In a large room, sparsely occupied, a half-hourly change is usually sufficient for satisfactory ventilation, while in a crowded audience room fair ventilation may hardly be secured by a complete volumetric change ten or twelve times per hour.

A LARGE MECHANICAL HEATING AND VENTILATING INSTALLATION.
The United Railways, Baltimore. Building 478 by 368 feet, served by four ¾-housed fans.
American Blower Co., Detroit, Mich.

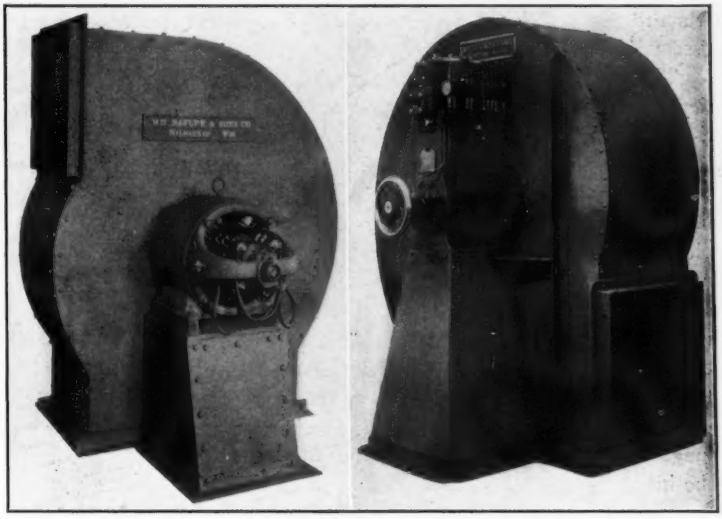
In a modern school building, with class rooms designed to allow about 250 cubic feet of space for each pupil, a supply of 30 cubic feet per minute per capita is equivalent to renewing the entire volume in the room once in about eight minutes. A supply of 50 cubic feet under similar conditions marks the attainment of excellent ventilation and is sufficient to change the air once in five minutes.

Heated flues are not only utterly inadequate for the movement of the air in such volumes, but are also excessively inefficient as compared with the fan, which may be employed to force the air



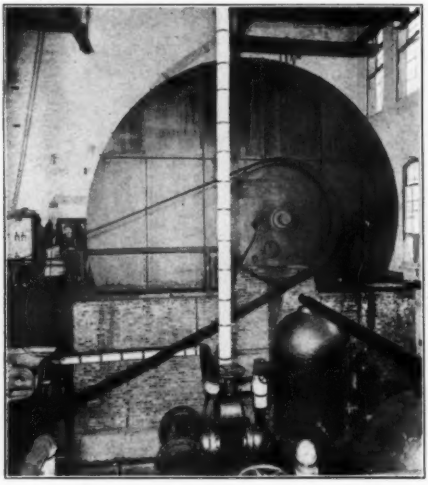
150-HORSE-POWER SIROCCO-BLOWER DIRECT-DRIVEN BY STEAM TURBINE.

through hundreds of feet of duct. In refined systems of ventilation the velocity of the air in process of transport usually ranges from about 2,000 feet per minute in the distributing mains, down to about 300 feet at the registers, while in factory practice, where the opera-



FORCED DRAFT FANS.

On the left, a full-housed 70-in. fan with direct-connected motor, delivering 11,700 cu. ft. of air at 623 revolutions. Wm. Bayley & Sons Co., Milwaukee. On the right, a 90-in. engine-driven fan by the B. F. Sturtevant Co., 500 revolutions, delivering 20,000 cu. ft. of air per minute at 3.5 in. water pressure.



FORCED DRAFT FAN, WORKS OF THE N. Y. GLUCOSE CO.

American Blower Co.

tives are usually in motion, main-duct velocities may be carried up to 3,500 feet per minute, and correspondingly high deliveries permitted if opportunity is given for the thorough breaking up of all currents before they reach the individual.

The more actively employed is the operative the less will he realize the movement of the air about him. Hence, one or two points of delivery with a limited distributing system may be all that are required in the boiler shop, while the refinement of an elaborate arrangement of outlets through which the air is discharged at lower velocity may be essential in the watch factory.

The fan is today rapidly superseding its predecessor, the chimney, as a means of draft production for steam boilers. Employed as a mere substitute for the chimney it may be installed upon the induced or suction principle, with short stack extending just above the roof and operated to create a pressure difference of 1 to 1½ inches of water. As an accessory to the chimney, particularly in an old plant or in combination with mechanical stokers, the fan finds ready application under a forced-draft system and may be operated at pressures up to even 3 or 4 inches of water, as is ofen necessary in marine practice or with some forms of mechanical stokers. For ordinary grates and fuel in stationary plants, the fan is seldom speeded to create a pressure of over 1½ to 2 inches at the outlet. Mechanical draft is, in effect, but the furnishing of air in sufficient volume for the lungs of the furnace, as is ventilation the equivalent supply of air for the human lungs.

Fig. 1. An Anthracite Breaker; Coxe Bros. & Co., Inc., Beaver Meadow; Showing Tower for Dumping Cage.

LABOR-SAVING DEVICES IN COAL MINING.

By R. V. Norris.

Mr. Norris' article is fitly grouped with the preceding two, since it carries the study of the same elements (labor-saving and mechanical-transport appliances) into the third great field of engineering activity—mining. And the concrete example chosen—coal mining—lies close to the foundation of almost all modern power applications.—THE EDITORS.

IN looking back over the twenty years from 1903 to 1883 in the anthracite mines, we find that in 1883 there were mined 35,703,009 tons by collieries employing 56,270 men and boys inside, and 35,153 outside; while in 1903, for a production of 67,171,951 tons, there were employed but 102,055 inside and 49,772 outside—or in 1883 one employee inside for 635 and one outside for 1,016 tons, and in 1903 one employee inside for 658 and one outside for 1,350-tons production. This comparison is a little in favor of the earlier year, when the colleries worked an average of 218 days against an average of 211 in 1903.

From this it is evident that while great economies in labor have been made in the surface handling and preparation, but little net improvement has been made in the underground work. This is accounted for by the great extension of all collieries both longitudinally and in depth, and also by the much smaller and poorer seams now

FIG. 2. THE "SPRY" HAND DRILL WITH STEEL AUGERS AND ADJUSTABLE BIT ENDS. Howell's Mining Drill Co., Plymouth, Pa.

being worked; these disadvantages have apparently nearly balanced the improvements in transportation, pumping, and ventilation which have been made in the past generation.

The outside economies are even greater than appear by the tonnage, as the quality of preparation of coal has very greatly improved until less than 2 per cent of slate is now tolerated in the larger sizes, while 15 per cent. and even more was usual twenty years ago.

Taking up the improvements they may be classed thus:—

INSIDE		**SURFACE (Continued)**	
Mining	Mining methods.	Preparation.	Picking platforms.
	Drilling and blasting.		Rolls.
	Handling.		Screens.
Transportation	Mine cars.		Automatic pickers.
	Haulage.		Jigs.
	Track.		Disposal or refuse.
Hoisting	Engines.	Steam Plants.	Boilers.
	Cages.		Grates.
	Safety appliances		Mechanical draft.
SURFACE			Economizers.
Transportation	Haulage.		Stokers.
	Track.		Pipe Covering.
	Car hoists.		
	Conveyors.		
	Elevators.		

The Engineering Magazine

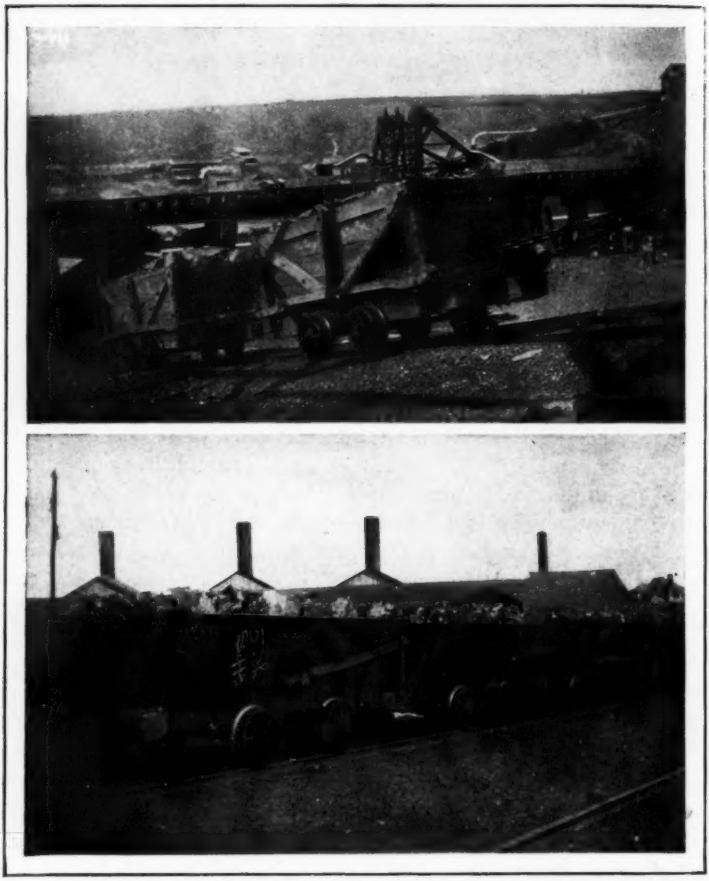
All of these points show notable improvements; and while a full discussion of many of them is hardly within the scope of the present article, a brief survey it is hoped may prove interesting.

The changes in mining methods are generally an advance in degree rather than in principle, the main improvements being in the line of better and closer mining, and more thorough recovery of the coal; to these should be added the actual advance in filling the old workings with culm slushed in through bore holes by the use of water, to support the roof and thus permit the recovery of a larger percentage of the coal in the ground, and the increasing use of steel and masonry instead of timber for the support of the mine roof in important openings.

The miner has eased his labor and increased his hourly output by the use of boring machines (Figure 2). These are usually of very simple construction, consisting essentially of a support wedged into the coal and a feed screw carrying a twist drill revolved directly by hand power; some few air and electric drills are used, but their application is limited to places where power is available, which in anthracite mining is not generally the case. While many undercutting machines are used in the bituminous region, they are not used in the anthracite on account of the exceeding hardness of the coal and a general lack of a soft "mining bench" underlying the seams, and because the prevailing room and pillar system of mining is not especially suited to their use.

The greatest advance inside has been in transportation, especially in the replacement of the original long-eared compound engine by air and electricity; this, as it is covered in another article, I shall only touch on to call attention to the advance in track construction, which twenty years ago was of the lightest—usually 16 to 20-pound rails, or even 3 by 5 inch wooden tracks—and has now advanced to 30 to 40-pound rails for main gangways and 60 to 80-pound for slopes, with really respectable frogs and switches; and to the advance in mine cars and running gear (Figures 3 and 4). The car of 1883 was entirely of oak, usually with plain loose outside wheels secured by cotter pins through the axles; these were lubricated (?) through an oil hole in the hub *at* which a boy squirted half a pint or more of oil whenever they came to the surface, with the result of fully oiling the ground along the breaker tracks. This type of running gear has generally been replaced by closed-hub self-oiling wheels using less than 1/5 of the old allowance of oil and reducing the running friction by 40 per cent.* The latest advance for outside wheel cars is the use of

* Trans. A. I. M. E. Vol. XVIII, p. 508.



FIGS. 3 AND 4. THE UPPER PICTURE SHOWS OLD-TYPE WOODEN MINE CARS WITH PLAIN WHEELS; THE LOWER ONE, MODERN STEEL CARS OF 100-CUBIC-FEET CAPACITY, 3,400-POUNDS WEIGHT, IN USE BY THE SUSQUEHANNA COAL CO., NANTICOKE, PA.

one fast and one loose wheel (Figure 5) which has the advantage of permitting the car to take properly the very sharp curves necessary in a mine, gives the advantage of a turning axle concentrating the wear on a removable brass in the journal box, and permits the "spragging" of one wheel. All-steel cars are just beginning to come into use; those shown just above were the earliest and were put in use only about a year ago; they have thus far been very successful and promise to come into quite general use. In car wheels the greatest advance is in

the use of manganese steel, giving much lighter and tougher wheels, and ones which do not readily wear flat.

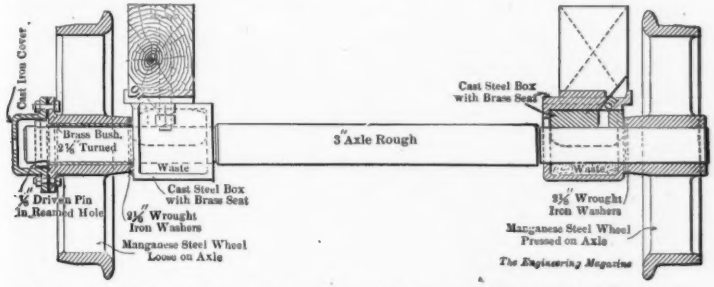

Cast Iron Cover
Brass Bush, 2⅛" Turned
Waste
¾" Driven Pin in Reamed Hole
Cast Steel Box with Brass Seat
2⅛" Wrought Iron Washers
Manganese Steel Wheel Loose on Axle
3" Axle Rough
Cast Steel Box with Brass Seat
Waste
2⅛" Wrought Iron Washers
Manganese Steel Wheel Pressed on Axle
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FIG. 5. RUNNING GEAR FOR MINE CARS; CAST-STEEL BOXES WITH BRASS SEATS. FAST AND LOOSE MANGANESE-STEEL WHEELS.

In hoisting practise has come the enlarged use of first-motion engines directly connected to large drums, the change from wooden to steel shaft cages, and the use of dumping cages. These take the loaded car at the foot of the shaft and automatically dump it without removal at the head, doing away with the greater part of the large head force required for handling the empty and loaded cars. The application of dumping cages is of course limited to locations where the coal dumped at the head of the shaft can be put either directly into the breaker or taken into it by conveyors, and in many if not most cases they are installed in breaker towers to take the loaded mine cars from the surface to the dump, thus avoiding the use of elevators or conveyors. As the Pennsylvania mine law requires a distance of 100 feet between the shaft and the breaker, their use for direct hoisting into the breaker itself is limited to plants erected before the enactment of the present law in 1891.

In landing cages, both at surface and bottom, pneumatic keeps are coming into use, the cage landing on a piston upheld by a spring and sinking into a cylinder the air in which escapes through a small opening; these permit of more rapid landing without dangerous jars. Crossover trucks for handling cars at the heads of shafts avoid the usual complication of switches and somewhat reduce the head force, while caging rams with long strokes, operated either by air or steam, pushing the empty car on and the loaded off the cage, are in satisfactory use at a few plants.

The pumps two decades ago were mainly simple, non-condensing direct-acting pumps, frequently of long stroke, 6 feet being very common, and running at a slow plunger speed, with a duty of perhaps 20,000,000 foot pounds per 1,000 pounds of steam; while in the latest

plants compound and triple-expansion condensing pumps are installed, and in one case at least, high-duty pumps of the flywheel type, with compound condensing Corliss engines. The pump houses, too, are now usually fire-proof, either driven in rock or lined with masonry, a lesson taught by the many mine fires starting in the old timber rooms.

After reaching the surface, anthracite is taken to the breaker and there sized and cleaned to a merchantable article; the handling between the mine opening and the breaker has been the subject of much attention resulting in immense improvement in the saving of time and labor. The general methods of handling may be classified as:—

Rope,	Chain.
Locomotive,	Conveyor,
Mechanical and Gravity,	Elevator,

all liable to be inter-dependent, the system adopted being usually a combination of two or more of the above.

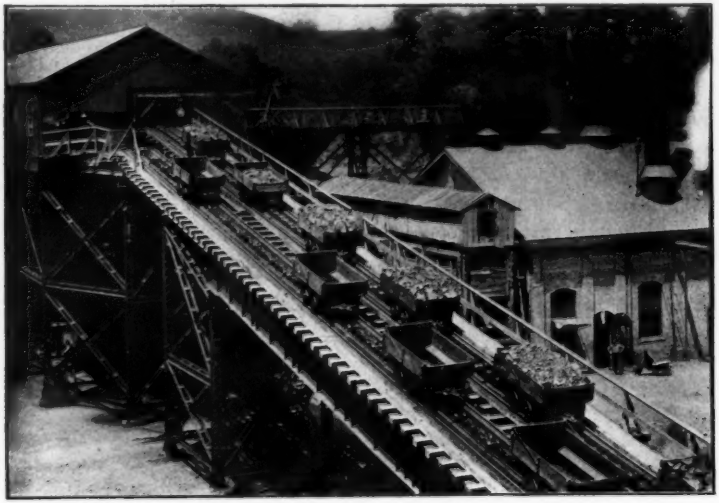


FIG. 7. CAR-HOIST OF THE NATIONAL MINING CO., TREVESKYN, PA.
Installed by the Link Belt Engineering Co., Nicetown, Philadelphia.

As mine cars require fully 2 per cent. grades for proper handling, gravity alone can be adopted for one direction only, the empty cars being returned to the mine opening, if near at hand, by rope or chain haulage,* or by the use of a light car hoist to elevate the cars at the breaker sufficiently to permit their return to the mine opening by gravity. This consists of a plane, usually of very moderate pitch, on which

* Trans. A. S. M. E. Vol. XII, p. 626.

FIG. 8. BUCKET CONVEYOR, PENNSYLVANIA COAL COMPANY'S NO. 14 BREAKER. This conveyor takes run-of-mine coal from a surface tipple to the head of the breaker. Similar conveyors with chain and scraper flights are in general use for this purpose. Installed by the Link Belt Engineering Co.

runs a chain provided with hooks at intervals; these catch the car axles and carry the cars to the desired elevation, when by the use of a sharp down grade they detach themselves automatically and run by gravity either to the mine opening or, if that is too far distant, to a yard. For any considerable distance beyond the possibilities of gravity handling, perhaps the most satisfactory method is the use of a small locomotive, handling the mine cars in short trains; such "Dinkeys" are usually from 8 to 12-tons weight and from 7-inch to 10-inch cylinder, with four driving wheels, no truck, and saddle tank; the drivers should be quite small, not only for power in starting but to avoid excessive speed which is ruinous to mine-car running gear.

At the breaker, where a hillside to give a level approach is not available, the coal is either dumped at the bottom into large conveyors (Figure 8, just above) or elevators, and thus taken to the top

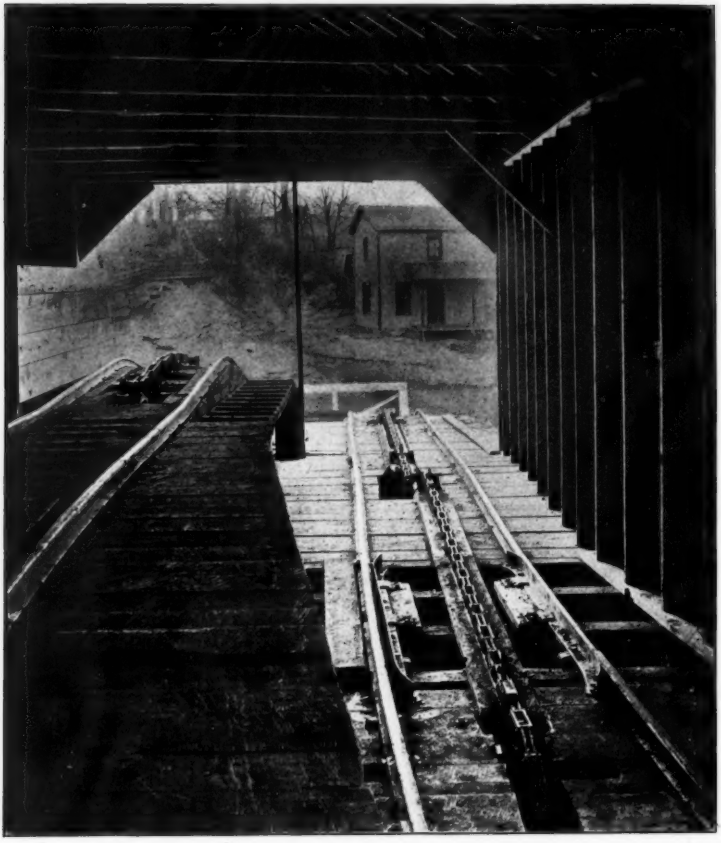


FIG. 9. HEAD OF CAR HOIST, SHOWING FEEDING CHAIN AND TRACK BRAKE.

of the structure, or the cars themselves are hoisted either by dumping cages (Figure 1) or on a plane either by a rope and pusher or by a car hoist (Figure 7). In the latter case the empties are brought down by a separate chain, the hoisting chain having hooks at considerable intervals to avoid overloading, while the lowering chain must have hooks spaced closer than the car lengths so that a car can by no accident miss catching, the upper part of the return chain being in this case on only a very slight grade so that the car may strike the hook without undue shock. A later device is the use of a feeding chain (Figure 9) which delivers the cars properly spaced to the main chain; a similar idea has been used at the foot of loaded planes,

the cars being started by a slow chain the hook of which is overtaken at a predetermined point by the hook of the faster main chain; this arrangement, which was first used at the Williamstown breaker of the Summit Branch Mining Co., considerably increases the capacity of a plane without subjecting the car axle to undue shock in picking up the car. It has been found that a speed much over 60 feet per minute for the hook will result in bent axles, while by the use of this starting chain it is possible to speed the main chain to nearly double that velocity, the starting chain at 60 feet picking up the car and the main-chain hook at 120 feet overtaking it and adding another 60 feet to the speed.

In the breaker itself the use of labor-saving devices is the most noticeable. It is necessary in preparing coal to take the rough mine product, containing from 20 to even 50 per cent. of impurities, and consisting of pieces varying in size from lumps weighing nearly a ton to impalpable dust; this material must be accurately sized and cleaned of practically all impurities.

The sizes as prepared for market are

Lump.....	over	6-inch	bars.						
Steamer.....	"	3½-inch	bars	through	6-inch	bars.			
or..	"	4½-inch	square	mesh	through	6-inch	bars.		
Broken.....	"	2¾-inch	mesh	through	4½-inch	sq.	mesh	or	3½-inch bars.
Egg.....	"	2 -inch	"	"	2¾-inch	sq.	mesh.		
Stove	"	1⅜-inch	"	"	2 -inch	"	"		
Nut	"	¾-inch	"	"	1⅜-inch	"	"		
Pea	"	½-inch	"	"	¾-inch	"	"		
Buckwheat ..	"	¼-inch	"	"	½-inch	"	"		
Rice	"	⅛-inch	"	"	¼-inch	"	"		
Barley.....	"	1/16-inch	"	"	⅛-inch	"	"		

The coal as dumped at the breaker first passes over bars with about 6-inch spaces, these being either stationary or of the Coxe oscillating type*, (Figure 10) then over lower steamboat bars with 3½-inch opening; the coal passing over both of these is hand picked, either on a platform, in broad shoots, or on a slow-moving picking belt. Here is separated the heavy slate and bone, many pieces coming from the mines being stratified so that it is necessary to remove the adhering slate from them by hand picks, it being of course most desirable to remove the slate in the largest possible pieces, especially as on the lump size one man will remove from 2 to 3 tons per hour, while in nut size a boy will pick but about 30 pounds of slate in the same time.

* Trans. A. I. M. E., Vol. XIX, p. 398.

The hand-picking arrangements must be so designed that the coal passes the pickers regularly and with a minimum effort on their part, and yet so that any doubtful piece can be readily stopped for examination or separation. From the bars the lump coal passes to the lump rolls for a first breaking down, and thence after further picking joins the steamboat coal and goes to the second rolls which break it to "broken" size and under.

FIG. 10. COXE OSCILLATING LUMP-COAL BARS, IN USE IN WILLIAMSTOWN BREAKER, SUMMIT BRANCH MINING CO.

The breaking rolls (Figure 12)* are constructed in the form of toothed cylinders driven together by gearing, the sizes, spacing and forms of teeth being suited to the coal to be broken; while there is a considerable variation in practise as to the teeth the general average would be about as follows:—

Lump rolls	Teeth	4 inches high, 4 to 5-inch centres.
Steamboat rolls	"	3 inches high, 3½ to 4-inch centres.
Broken coal rolls.....	"	2½ inches high, 2¾ to 3½-inch centres.
Bone rolls	"	1 to 1¼ inches high, 1¼ to 1½-inch centres.

The diameters of the shells vary with the size of coal, later practise tending toward larger rolls of less length; the large shell permits better splitting action of the teeth, while with small diameters there is a tendency for large pieces of coal to revolve and partially disintegrate before passing through.

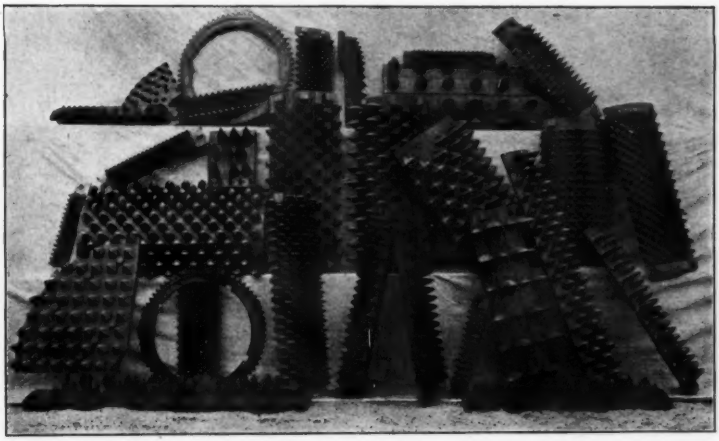


FIG. 11. MANGANESE STEEL SEGMENTS FOR ROLLS, SHOWING VARYING DESIGNS IN SIZE, SHAPE, AND ARRANGEMENT OF TEETH.
The Taylor Iron & Steel Co., High Bridge, N. J.

The earlier roll shells were made of cast iron with cast teeth, the points occasionally chilled; these wore rapidly and had the further disadvantage that a broken tooth or two necessitated the replacement of the entire shell. Such rolls have practically passed out of use, the

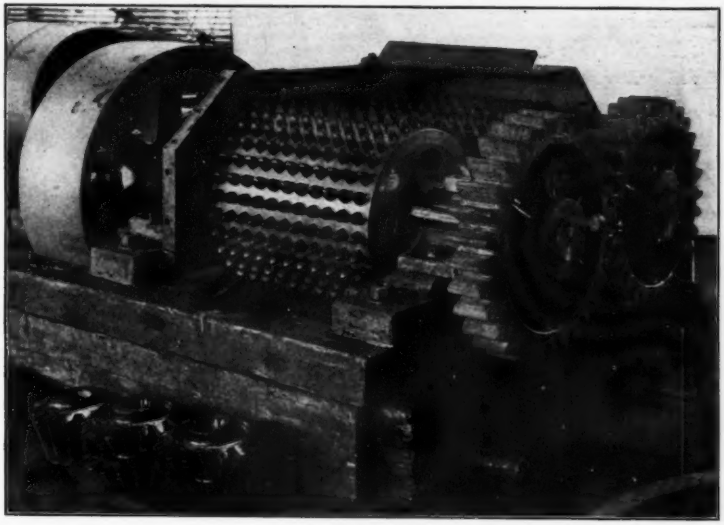


FIG. 12. PREPARED COAL ROLLS.
Built by the Vulcan Iron Works, Wilkes-Barré, Pa.

FIG. 13. SHAKING SCREENS INSTALLED IN A BREAKER.
Vulcan Iron Works, Wilkes-Barré, Pa.

present practise being the use of heavy cast-iron or steel shells with forged-steel teeth driven into reamed holes; these when badly worn are broken off, the stems driven through, and replaced by new teeth. Within the last few years a great many rolls have been constructed of the segmental type with cast manganese-steel segments, either longitudinal or circumferential (Figure 11); these are readily replaced and are coming into very general use, especially for small-size coal where the immense number of teeth—2,100 for a pair of bone rolls 25 by 27 inches—makes the use of inserted steel teeth very costly. The photograph shows well the very varied practise in tooth arrangement and shape, and near the right-hand lower corner the use of large and small teeth in the same roll for lump or steamer coal. Corrugated rolls, invented by the late Eckley B. Coxe, are used to some extent, and appear to be particularly suited for pure coal; these were fully described in the Trans. A. I. M. E., Vol. XIX., p. 398.

From the rolls the coal goes to a series of screens for sizing; these are either round screens, shakers, or gyrators. The earlier practise was to use round screens exclusively, with a few not very successful innovations in the direction of polygonal screens, but within the last ten years practise has been gradually veering to shaking screens

(Figures 13 and 14) to such an extent that for the sizes below stove they are almost exclusively used in modern plants, and are used for all sizes by several of the large companies. Shaking screens, as compared with round, have the advantages of greater capacity, are lower in first cost and probably in repairs, and lend themselves very well to the application of water; they do, however, subject the breaker to considerable vibration, so much so, that it has been found essential to hang them in balanced pairs.

After sizing, the coal still contains large amounts of impurities and it is in the mechanical elimination of these that the greatest advance has been made. While the larger sizes, broken and egg, are usually hand-picked, the greater part of the impurities in the sizes from stove coal down are now removed by mechanical means.

The mechanical pickers may be generally classed as wet and dry.

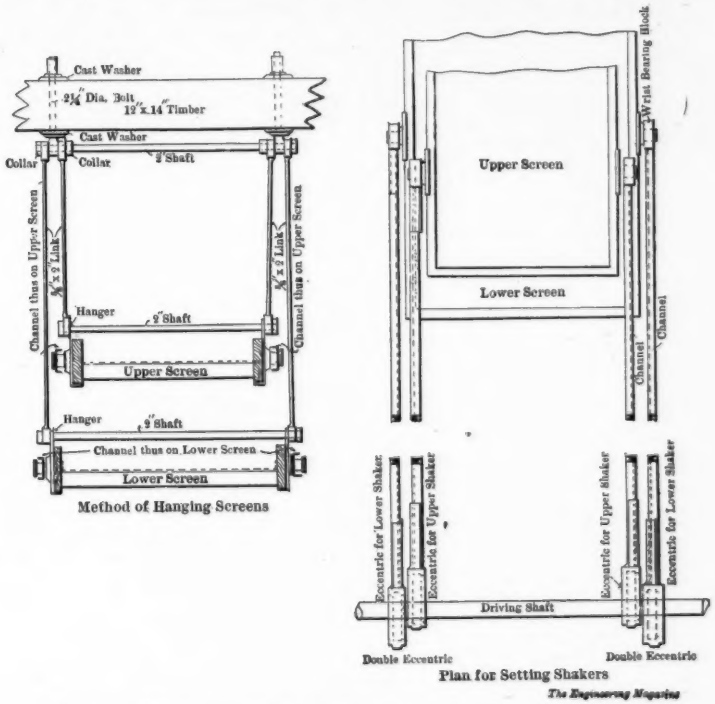


FIG. 14. GENERAL ARRANGEMENT OF SHAKING SCREENS, NO. 7 BREAKER, SUSQUEHANNA COAL CO., NANTICOKE, PA.

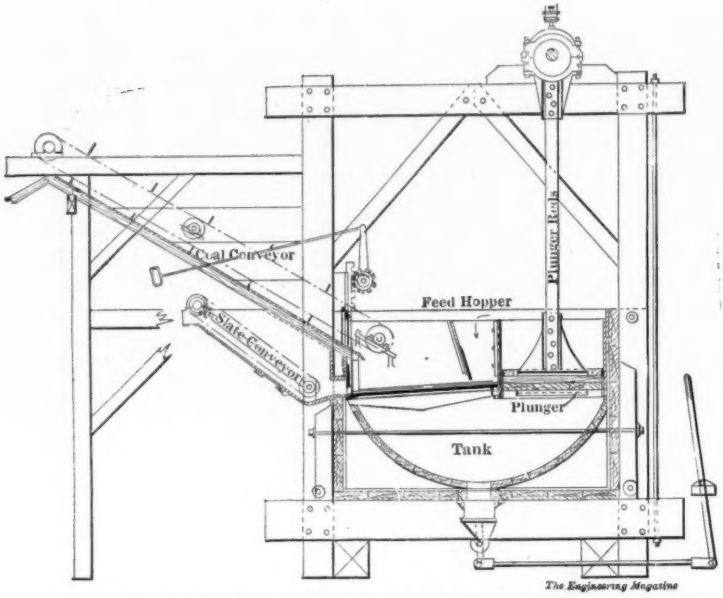


FIG. 15. STANDARD FOUR-FOOT JIG, SUSQUEHANNA COAL CO., MINERAL RAIL ROAD & MINING CO., LYKENS VALLEY COAL CO., SUMMIT BRANCH MINING CO.

the former including the various forms of jigs, of which two general types are in use—plunger jigs (Figure 15) in which the necessary pulsation of the water is accomplished by the use of a reciprocating plunger, the coal and slate layers being removed either by conveyors as shown or by elevators or occasionally by a combination of the two; and pan jigs, in which the pan itself forms the plunger and is churned up and down in a tank of water, the coal and slate discharging into separate hoppers from which they are raised by elevators; these have the advantage of compactness as compared with plunger jigs, but the cost of repairs is liable to be somewhat increased as a result of the reciprocation of the large pan of coal.

The varieties of dry pickers are numerous, each suitable for certain conditions; for the flat slate a simple angle bar with tapered slot (Figure 17) answers admirably; these have large capacity, the Fern picker being said to have a capacity of 4 tons per hour per foot width, and with the drop opening at the end of the bars will also remove a certain amount of heavy rock. Similar slot pickers are often cast cylindrical and attached to the end of round screens with good results. Another type uses a slate table to retard the slate, with a

drop slot to be jumped by the coal, but into which the slower-moving slate falls; of this type the Emery pickers are an example and are largely used in certain districts where the character of the coal is suitable. Another and unique type of dry picker is the the Pardee spiral picker (Figure 18); this consists of sheet-iron or bronze spirals with adjustable pitch, so arranged that by centrifugal force the free running coal is thrown over the edge of the inner spirals and caught in the wide outside casing; the bone runs near the outer edges of the small spirals and is delivered into a separate shoot from the slate, which by reason of its poorer sliding qualities has a tendency to run close to the axis. These for certain coals are very successful, particularly when the mid-product is either run to jigs or to a second spiral; the capacity of each is about 4 to 6 tons per hour, and the separation between coal and slate good; the middle product, however, as noted, is apt to be too rich to throw away, and requires further treatment. The very general employment of these various types of mechanical pickers accounts in a large measure for the reduction in outside labor per ton of production, although the larger sizes are still generally hand-picked

FIG. 16. JIGS IN COXE BROS. & COMPANY'S BEAVER MEADOW BREAKER.

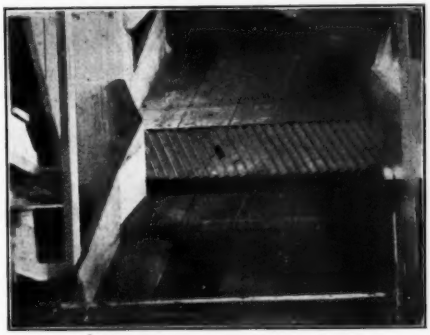


FIG. 17. FERN PATENT ANGLE-BAR SLATE PICKER, FOR FLAT SLATE AND HEAVY WORK.
John Fern & Son, Scranton, Pa.

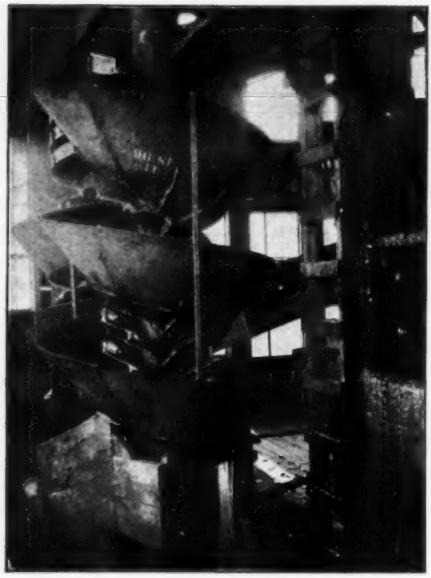


FIG. 18. PARDEE SPIRAL PICKER, IN THE WILLIAM PENN BREAKER, SUSQUEHANNA COAL CO.

This picker makes three separations—coal, slate, and bone—by centrifugal force. Made by Anthracite Separator Co., Hazleton, Pa.

and usually the mechanically prepared coal is given a final hand-picking before going to market. An excellent arrangement of picking shoots is shown (Figure 19), where the coal passing down a central shoot is all drawn off by cross shoots, at each of which a boy is stationed who passes the coal by hand, examining it on the way, into side shoots through which it goes to the pockets.

In steam practise the past twenty years have witnessed not an improvement but a revolution. As late as 1886 there were practically nothing but plain cylinder boilers used in the anthracite region, there being but a very few locomotive and return-tubular boilers and fewer of the water-tube type, while today all the large producers and many of the individuals have changed practically their entire steam plants to either the return-tubular or water-tube types; of the latter the B. & W. and Sterling appear to have the preference, with a number of Hazleton, Clonbrock, Heine, Root, Finger, and similar types, while the return tubulars used are mostly 72-inches diameter by 18 feet long. This change has been brought about principally by the introduction into the market of the steam sizes of coal, which were formerly a waste product, changing a valueless refuse into a material which had to be accounted for; and when it is considered that an ordinary colliery uses about 10 per cent. of its entire output for steam purposes, the necessity for economy in fuel is apparent. The burning of the very fine sizes has brought great changes in grates, greatly increased grate areas, and an increasing use of forced draft. While the old cylinder boilers were usually provided with steam blow-

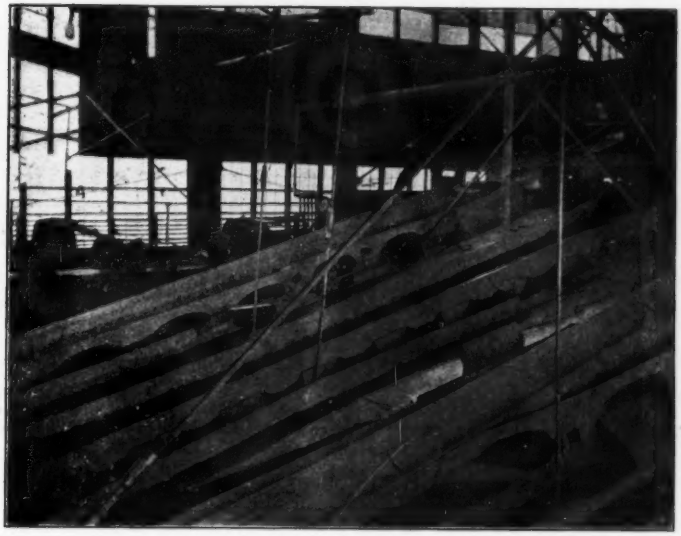


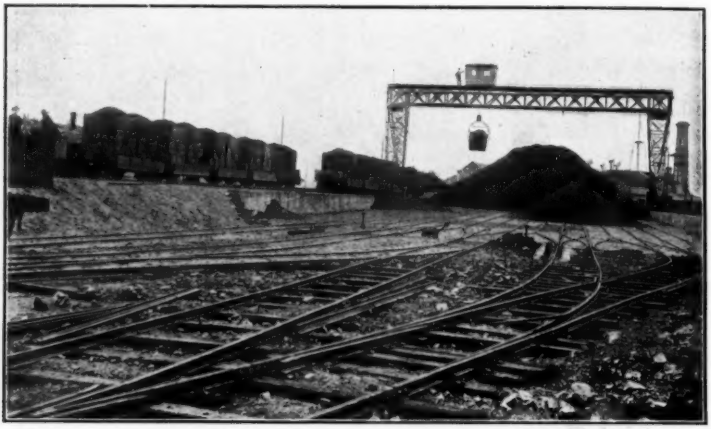
FIG. 19. PREPARED COAL-PICKING SHOOTS, DRIFTON BREAKER, COXE BROS. & CO., INC.

ers, often home-made, which pre-empted from to to 15 per cent. of the total steam, the modern plants have generally improved steam blowers of the McClave or similar types, with a growing tendency to the installation of fan blast; while two or three plants, notably those of the Lehigh Valley Coal Co., at their Packer No. 4, and of the Delaware, Lackawanna & Western R. R. Co. in Keyser Valley, Scranton, are supplied with forced and induced draft and economizers, the latter having also stokers and superheaters. Stokers have thus far been but little used, the plant above mentioned and a few of those of Coxe Bros. & Co., using the Coxe stoker, being the only ones which have come under my observation.

In the good old days any old kind of steam-pipe covering for large pipes, and frequently none at all for small—and even for large ones—was the rule; while at the present time practically all steam pipes are being protected with the best coverings in the market; for the larger ones there is even added an outside inch of hair felt to the usual magnesia or asbestos coverings.

The use of electricity and of compressed air for colliery purposes is rapidly increasing* and it appears to me that the most notable economies in the immediate future are to be looked for in the power plants rather than in the mining or preparation.

* Trans. A. I. M. E., Vol. XXXIV, p. 512.



COLIATH CRANE HANDLING MATERIAL FROM RAILWAY WAGONS, WALLAROO & MOONTA MINING & SMELTING CO., LTD., AUSTRALIA.

Made by Royce, Ltd., Manchester, England.

LABOUR SAVING IN THE HANDLING OF MATERIALS.

By Arch. J. S. B. Little.

Mr. Little takes up the general application of conveyor systems to industrial and manufacturing plants, extending the use of engineering appliances even outside the field of the strict engineering occupations.—THE EDITORS.

DESPITE the demand for complete efficiency in all that relates to engineering work, the attempts which have been made to apply mechanical means to the transport of materials during process of manufacture have been comparatively few and non-heroic. Nevertheless, it cannot be denied that in most instances where conveyor specialists have been invited to lend their aid, improvements have resulted, and these very frequently after confident predictions of failure by those for whose benefit the work was primarily designed.

One of the purposes of this article is to show how improved methods have increased the productive power of a given period with a more or less corresponding reduction in human toil; and I propose to deal with plants used in various industries, making the cases brought under observation as divergent as possible, to the end that one or other may appeal to the inquirer, especially in view of the pos-

sibility of like methods being applicable to a different, yet in some measure allied, industry.

Little is known of such apparatus employed a hundred years ago. Extant records are most imperfect, and little can be learned from the personal experience of manufacturers. Works were usually small, while means of communication were slow and expensive, and one factory-master would consequently be ignorant of new methods of handling materials in use by his competitor. The few who recognised the importance of the question were no doubt compelled to design the apparatus themselves, aided probably by the maker in the person of a local millwright.

I recently came across a record of the operations carried on at the Soho Foundry by Boulton and Watt, in making the coins for which they became so famous. The writer, evidently a great admirer, referred to the plant of 1788, and, after explaining the (at that time) unheard of speed and accuracy in turning out eighty coins per minute, went on to say that "the sheets, after being laminated and cut in one room, were taken by an endless conveyor to another, in which was situated the press worked by one small boy" *(sic)*.

Some twenty years ago, when the first conveyor company commenced to supply automatic machinery for moving materials, there

PIPE-COOLING CONVEYORS FOR TAKING HOT PIPES FROM THE WELDING MACHINE, SHARON STEEL CO.
Link Belt Engineering Co.

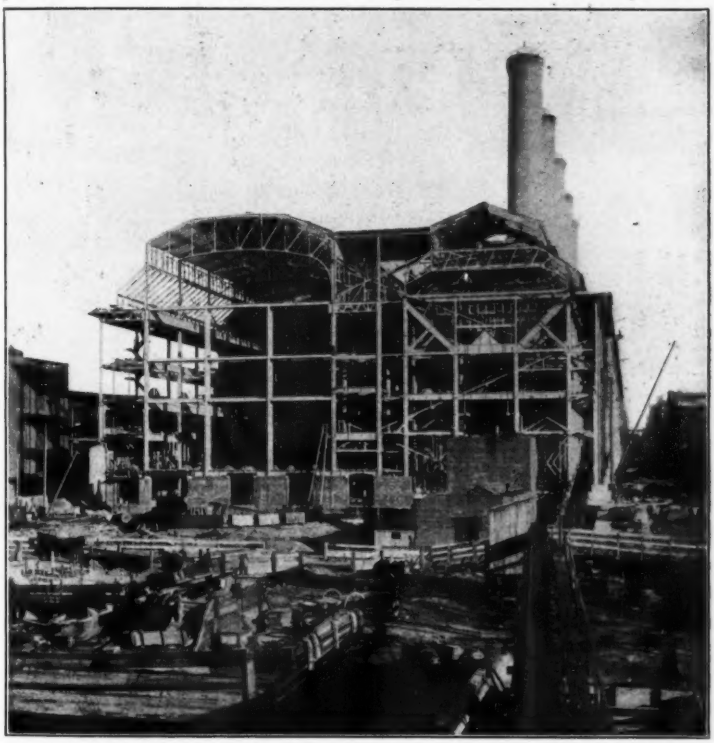
CONVEYOR FOR BARRELS, BAGS, AND MISCELLANEOUS PACKAGES, NEW YORK GLUCOSE CO., EDGEWATER, N. J.

1200-ft. centers, capacity 800 barrels an hour, speed about 40 ft. a minute; reversible drive, operated by alternating-current motor taking about 15 horse power. Built by the Mead-Morrison Mfg. Co., N. Y.

was practically no demand for such appliances, and the designers had, in the first instance, to discover situations where their plant could be advantageously applied, and then to convince the mill owners that by its adoption, the capacity of the works would be increased and the labour-cost reduced. Gradually, however, a demand was created, additional companies were established for manufacturing conveyors, older firms added that branch to their business, and in a few years the whole subject was put on a scientific basis and studied in various offices by independent engineers. Thereafter, the introduction of appliances for transporting materials was exceedingly rapid.

The well-known spiral, or screw, conveyor was brought out in 1890. Its application to modern plants is still extensive, notably for feeding coal to boilers and gas producers. In the plant installed by the Power Gas Corporation at the works of Monks, Hall & Co., of Warrington, coal trucks, carrying 10 tons, are shunted to one end of a row of four Mond-type producers, and are emptied into a hopper with a capacity of, approximately, 450 cubic feet, which has on its underside an automatic agitator and feeder. This unloads the coal gradually from the hopper, being driven by gearing from the elevator, so that any variation in the speed of the buckets is also felt on the feeder, and consequently overloading cannot take place.

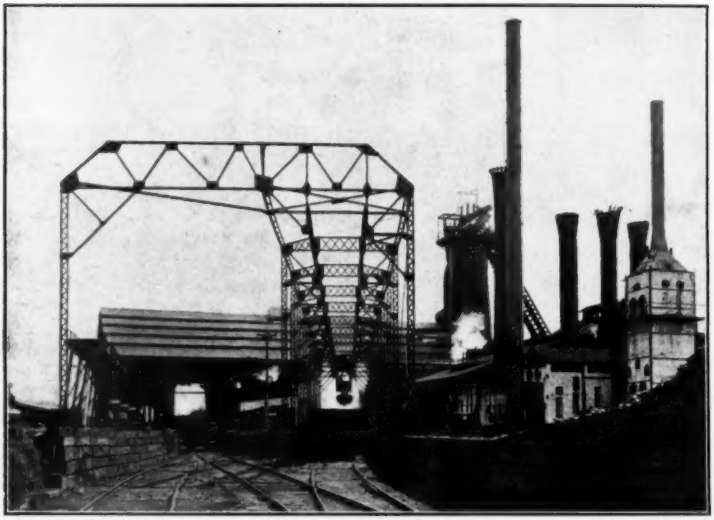
Several serviceable patterns of automatic feeders are made by the leading conveyor makers, and one should always be put in under a hopper which feeds an elevator and conveyor, and where coal is dumped by mechanical means. I also advocate the use of a screen of bars, set a few inches apart and fixed over the hopper to keep out large pieces of coal or foreign material which might injure the machinery. In the plant to which reference has been made, the coal is raised by a cased steel bucket elevator to a height of 60 feet and delivered into an 18-inch diameter worm or spiral conveyor, 80 feet long. In the steel trough of this there are, over each hopper, two outlets with controlling doors to allow exit of coal, there being also a hopper over each gas producer. The coal is automatically transported from the trucks, at the rate of 30 tons per hour, to a position



BELL-CONVEYOR SYSTEM, POWER HOUSE OF THE N. Y. INTERBOROUGH COMPANY ("SUBWAY").

The conveyor from the wharf front is seen on the right; by a series of long zigzag inclined belts, clearly seen crossing the open frame of the structure, the coal is carried to the bins at the top of the station. Robins Conveying Belt Co., N. Y.

suitable for charging the producers. A 6-horse-power electric motor, employed to drive the plant, is situated at the head of the elevator. One man is required for oiling and two others for emptying the trucks. The combined wages should not exceed 1s. 6d. per hour, and, as the plant can raise in that time 30 tons, the labour cost is approximately 2/3 of a penny per ton raised. The cost of machinery, including motor, hopper, elevator and conveyor would be less than £600. This type of plant is manufactured by most of the conveyor makers.



CINDER-HANDLING PLANT, PERKINS & COMPANY'S FURNACES, SHARPSVILLE, PA. The water-granulated slag is handled by a clam-shell bucket, 2 cu. yd. capacity; 40 trips per hour; runway 230 ft. long, covering pit and five gondola cars. Browning Engineering Co., Cleveland, O.

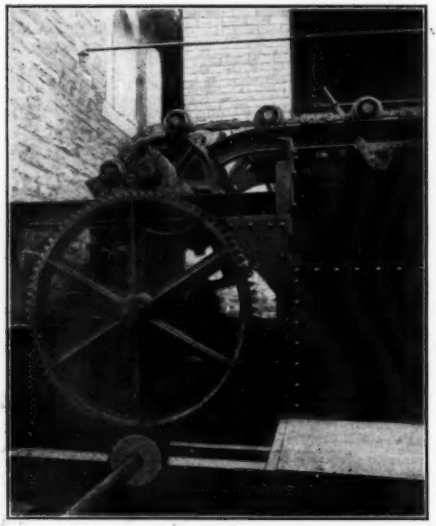
For larger Mond or Duff gas plants, such as those erected, or in contemplation, for generating power gas for distribution to consumers, a different but even more successful style of plant is required, and this generally includes hydraulic rams to tip the trucks, or Hone grabs for unloading the barges; while the conveyors are altered to either the pushplate, or the gravity bucket design. In handling 60 tons per hour, the cost of labour, with a plant of the last named pattern, would be reduced to about 7/16 of a penny per ton, but to secure this low figure, the capital outlay for a plant to deal with six producers is nearly £2,000.

A digression at this point may be excused, in order that consideration may be given to advances which have been made with the gravity bucket conveyor. Among the photographs in-

cluded in this article will be observed one of this type of conveyor of the usual design, with, however, an improvement in the construction of the buckets and tipping gear, the former being made in one piece instead of in three with riveted joints, and the latter being provided with anti-friction rollers. This conveyor is made by the New Conveyor Co., Ltd., and is in operation at the electric power stations of the Manchester, Sheffield, Newport and Leeds Corporations and of the Mersey Electric Railway. The type made by Graham Morton & Co., Ltd., varies in the chains, these being made of less depth and greater width, without bushes, and with the carrying rollers overhanging. Conveyors of this description have been supplied to the electric power stations at Yoker, Neasden and Motherwell.

GRAVITY BUCKET CONVEYOR, NEWPORT (MON.) TRAMWAY POWER STATION. Handles coal and ashes; capacity 100 tons an hour, speed 45 ft. per minute. New Conveyor Co., Ltd.

Some months ago, I patented a chain for use on this design of conveyor, which has been adopted in the large power house at Greenwich by Mr. Rider, engineer of the Tramways department of the London County Council.



DRIVING GEAR FOR GRAVITY BUCKET CONVEYOR.
Drakes, Ltd., Halifax.

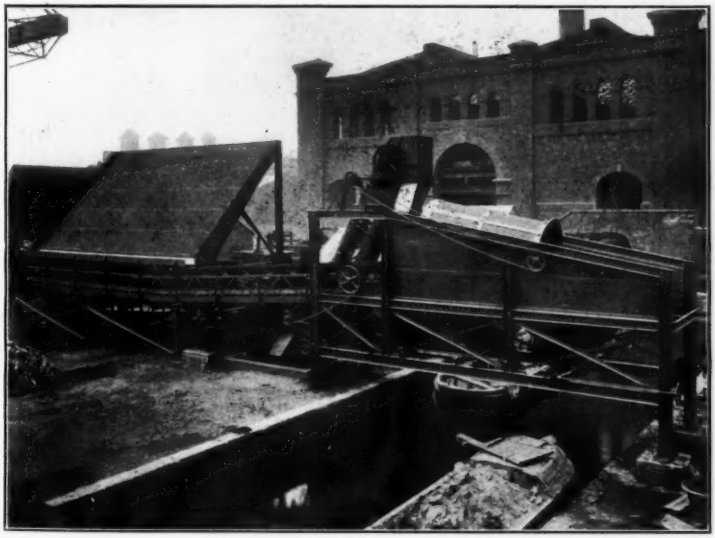
Attempts have been made at various times to design a satisfactory conveyor with overlapping edges on the buckets, and patents, taken out in America by the C. W. Hunt Co., the W. A. Mead Manufacturing Co., and others, have for their object the prevention of spilling of the material and the non-use of the automatic filling device. The difficulty, of course, is to get the buckets to unlock when they alter from a vertical to a horizontal travel. I have found that this can be effected, but at the expense of efficiency and durability, and heretofore it has appeared desirable to remove the attached lips and revert to the ordinary close-butting edges. Quite recently, however, another design has been introduced by R. Dempster & Sons, Ltd., of Elland, with the hope of solving the difficulty.

The feature of this conveyor is the form given to the buckets, of which the bodies are cylindrical and the ends circular, each bucket being provided with two over-lapping lips. A compensating gear of somewhat different design, but to accomplish the same purpose, was invented some years ago by the Link Belt Engineering Co., of Philadelphia, and manufactured in Great Britain by the Chain Belt Engineering Co., of Derby. The chains of Dempster's conveyor differ from those usually employed on gravity bucket conveyors, being made without rollers, these being mounted separately in bearings attached to the framework and made to carry the travelling chains. A working model of this "Tipit" conveyor attracted considerable attention at the International Gas Exhibition held at Earl's Court in November-December last.

Reverting to the spiral conveyor, I may say that suitable conditions for its introduction exist in dust destructor plants, where paving slabs are manufactured, and the process includes the feeding of

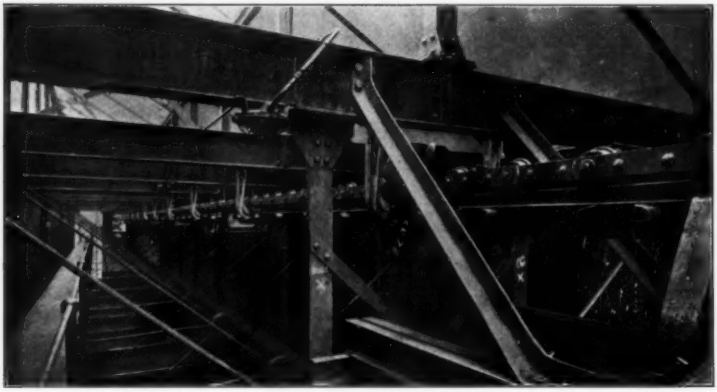
clinkers to and from the crushers and granulators into an elevator, which raises the reduced refuse to a pan-mill, into which is also fed the cement in regular pre-arranged proportions. The resulting mixture is then treated in presses. Machinery of this kind is manufactured by Fielding & Platt, Ltd., of Gloucester, and can be seen working at the destructor of the Fulham Borough Council. Spiral scraper, plate, belt, shuttle and other conveyors have also been applied successfully in the manufacture of asphalt, patent fuel, cement, paper, fish-manure, oxide of iron, pens, malt, beer, whiskey, acetylene, gunpowder, matches, salt, glass, etc., all with a saving in the labour item of the wage sheet. By using jacketed troughs and introducing live or exhaust steam, or by building the trough over hot-air flues, these conveyors can be used as drying machines. Mavor and Coulson, Ltd., apply the spiral conveyor to their coal-washing plants, and, where coke ovens are worked in conjunction, the disintegrated coal is similarly conveyed to the charging machine from the large hoppers, which are usually fed by means of aerial ropeways. As a typical instance of this application, mention may be made of the plant designed by Mr. J. H. Darby, and manufactured by the Pearson & Knowles Coal & Iron Co. for the Wigan Coal & Iron Co., Ltd.

Passing to the consideration of other forms of conveyors, I pro-



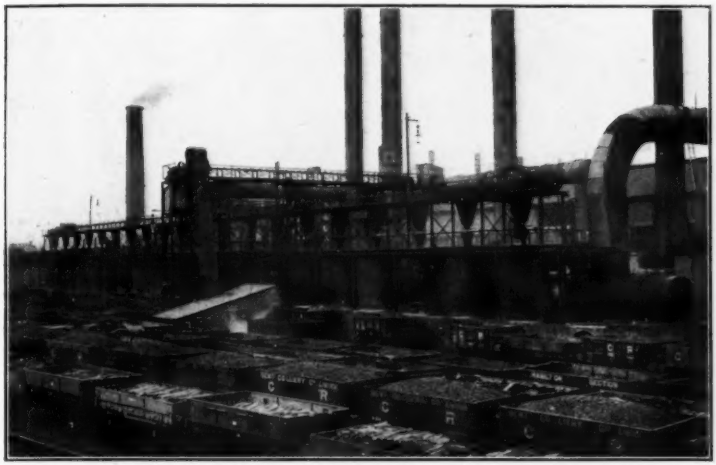
COKE SCREENING PLANT FOR LOADING BARGES, SALTLEY GAS WORKS, BIRMINGHAM.
Erected by R. Dempster & Sons, Ltd., Elland.

pose, for the sake of contrast, to describe those in use in the large-unit power houses of electric generating stations. Conditions here were so different from anything coming under the every-day notice of the conveyor maker that an application of existing designs was quite out of the question. The gravity bucket conveyor, now used and to which I have already referred, consists of two endless chains made of steel bars about 12-inch pitch with 1-inch joint pins and intermediate roller pins for the driving pawls. The chains are coupled together with 1-inch diameter bars 2-feet pitch, which act as distance pieces, and on the intermediate pins the buckets are hung. These are made to carry, in ordinary work, either 1 or 2 hundredweight of coal, and are mounted on the chains to form a practically continuous row. The chains are provided with 5-inch diameter carrying rollers at 12-inches pitch. As regards the arrangement of the plant, it may be convenient to take the case of a station which receives its fuel in trucks at one end of the boiler house. In England these trucks, holding 10 tons, are shunted over an underground hopper, and on the bottom or side doors being opened, the coal is partly dumped and the balance shovelled out by a labourer. Here is a point which is still open to improvement, for, excepting one instance, the hydraulic tipper usually seen at steel works has not been used at an electric station.



CONVEYOR, OLDHAM ELECTRICITY WORKS, SHOWING RUN OF BUCKETS OVER COAL BUNKERS.
Babcock & Wilcox, Ltd., Renfrew, Scotland.

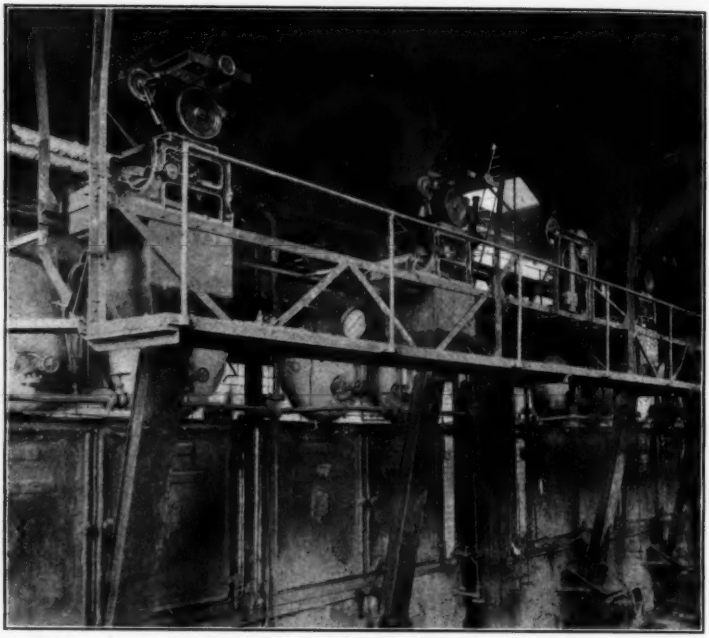
An arrangement now in operation at the Tramway Station at Newport, Monmouthshire, consists of a vertical cylinder, in which works a ram having at its outer end a V jaw, which, on receiving motion, raises the truck by one axle, using the other as a pivot; on the



COAL-HANDLING PLANT FOR DEALING WITH 60 TONS AN HOUR.
Speed of conveyors 70 ft. per minute; buckets 36 in. wide; each section separately driven by electric motor. The automatic tipper is near the small building in the centre of the yard. Built by the New Conveyor Co., Ltd., on Little's patents, for the Lanarkshire Steel Co., Motherwell.

door at the opposite end of truck being opened, the coal is tipped automatically into the hopper, and time is thus saved in getting trucks ready for removal. Other arrangements worked by direct gear have been manufactured by Ransomes & Rapier, of Ipswich, and West's Gas Improvement Co., Ltd., of Manchester. Where large coal is received, a crusher is placed under the hopper to reduce the coal to a size suitable for the automatic stokers and weighers. The coal from the hopper is fed into the centre of a revolving box, which opens only into the buckets as they pass underneath; consequently the latter are filled without any spill. The conveyor then rises vertically inside the boiler house wall and horizontally over the bunkers, where fixed adjustable or traveling tippers turn the buckets on their own axis through part of a revolution, and upset the coal into the bunkers. The conveyor returns under the boiler-house floor, where a travelling filler receives the ashes through floor shoots and directs them into the buckets, which, in their progress, carry the ashes to a hopper placed at any convenient point in the path of the conveyor. Machine stokers are used on the boilers, and the fuel is fed thereto by automatic registering weighers, so that every section of the transporting and handling plant is self-acting when cared for by two men.

A new form of gravity bucket conveyor, designed by myself, has been adopted at Hull for loading coal to stores. In this case the re-



AUTOMATIC COAL WEIGHERS IN CONNECTION WITH CONVEYOR SYSTEM, NEWPORT POWER STATION.

W. & T. Avery, Ltd., Birmingham.

turn strand passes under the stack, in a culvert in the stores, lifting and loading the coal into a separate elevating plant which feeds the overhead hoppers. The same type of conveyor used at the Sculcoates Gas Works in conjunction with the hot-coke conveyors, from which it receives the quenched coke and distributes it over the yard. Again, at the Hanley Gas Works, it puts the coke into stock or feeds it over screens, direct to the railway trucks, while the return strand of the cross-conveyor, which works in a covered tunnel, lifts the coke from the yard and directs it over the screens to the wagons. This is the first time such a conveyor has been used for reloading coke from stock and delivering to consumers' trucks. The improvements on this conveyor are in the construction of the endless chains and buckets, the carrying rollers, also, being provided with means for lubricating the pins while the conveyor is working, the bosses being screwed on the outside and fitted with grease cap.

In all overhead stores where coal is transported mechanically, automatic machines are used to weigh or measure the coal taken out. The

general principle of the weighing machine which is applied to boiler houses is too well-known to require detailed description.

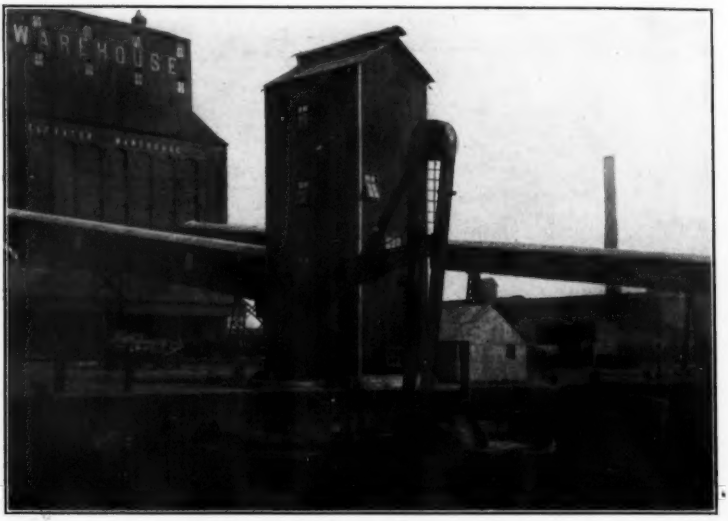
For handling material in bales, bags, packages, or light boxes, a recent type of conveyor, in which a woven-wire band is employed, has been found generally satisfactory. The band woven by N. Greening & Son, of Warrington, has been in use for a number of years at mines for picking conveyors and carriers, but Blake Barclay & Co., of Greenock, were early to see its advantage for the purpose of general conveying. In the first instance, the wire band was supported and driven in the same manner as that adopted on rubber and cotton-band conveyors. A plant was constructed on these lines for Adams Chemical Manure Co., to carry 200-pound bags of chemical manure, with a capacity of 60 tons per hour, over a distance of 400 feet, the conveyor being reversible to take the bags from the wharf to the factory and *vice versa*. On later installations considerable improvements have been introduced by Blake, Barclay & Co., the transporting band being so constructed as to act as a combined elevator and conveyor. This is accomplished by adding cross bars, which are attached to the wire band, and have their ends formed to act as spindles, on which run rollers to carry the band. Thus the friction is considerably reduced, as compared with the old method of using carrying rollers independent of the band and revolving in bearings attached to the framework.

HAY CONVEYOR, MIDLAND RAILWAYS PROVENDER STORES AT OAKHAM.

Designed and installed by Spencer & Co., Ltd., Melksham.

Another form of conveyor used for packages is the cotton-band type, which finds special favour in flour stores. Henry Leetham & Sons, of York, use it for conveying full bags of flour and offal, from one end of the store to the other, for loading into railway wagons. These conveyors, of which there are two, are about 300 feet long, and

the sacks, weighing 280 pounds each, are fed onto the conveyor, down a shoot sufficiently rapidly to load twelve railway wagons per hour. At the delivery end there are two lines of rails, and while one wagon is being loaded a full one can be drawn out, from the other



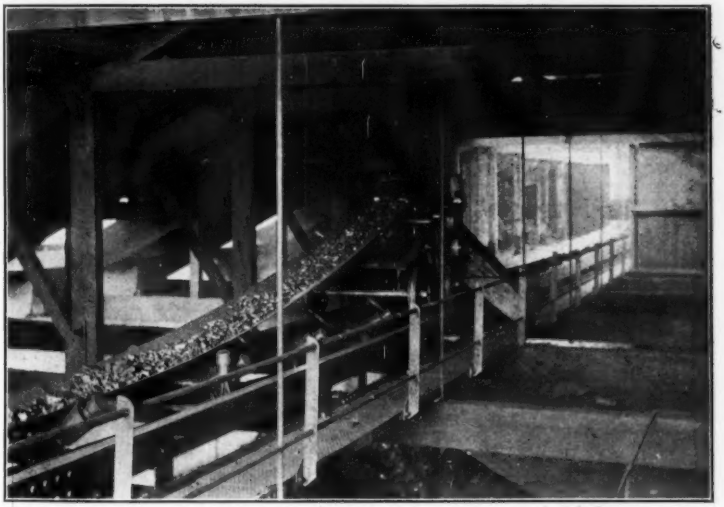
SELF-BALANCED BARGE ELEVATOR, LEITH DOCKS.

The grain is discharged from the barges, weighed in 5-ton lots in a weighing machine, and passed through a gantry band conveyor to silo ware house. Capacity 120 tons an hour. Spencer & Co., Ltd., Melksham. A larger elevator, serving ocean-going vessels, has a capacity of 350 tons an hour. All the machinery is under control of the operator in the tower.

siding, and an empty one substituted. This plant was installed by Spencer & Co., Melksham. In other pages will be found illustrations of some very interesting installations, all electrically-driven, for which this firm is responsible. Among these, special mention may be made of the grain discharging elevator recently erected at Leith Docks.

Some years ago the Robins belt conveyor was introduced into mines by an American company, who gave a great deal of attention to the materials and construction of the belt and concomitant parts. The former is built up with a woven cotton belt as a foundation, this being made thin in the middle portion, and then rubber is added to fill the interstices and cover the cotton. The result is a belt of great strength, presenting a surface of rubber; and, owing to the thinness of the cotton in the centre, the belt is very flexible, and can be curved by using triple idler rollers with the out-

side ones set on an incline. It is thus possible to get a large load on the belt and run it at speeds up to 600 feet per minute without fear of spilling. This conveyor is simple in design, takes little power to drive, and has a long life, with little expense, even when dealing with gritty materials such as the rock, ore and tailings at gold mines. It is used for handling coke at the gas works, Everett, Mass., conveying a distance of 200 feet up an incline of 21 degrees at the rate of 200 tons per hour, with a belt speed of 500 feet per minute. At the Pennsylvania Coal Co., Pittston, culm is fed to a movable hopper by means of a steam shovel, and even delivery is ensured to the screens at the washery. As the heap recedes, the railroad carrying the steam shovel is shifted and the conveyor moved bodily, sideways, close to the bank. These conveyors are 24 inches wide, 250 feet long each, speed 600 feet per minute and capacity 250 tons per hour. The trippers used on these belts, for discharging the load at intermediate points, can be made self-moving. These trippers are mounted on rails and have two pulleys which make the belt take the form of an

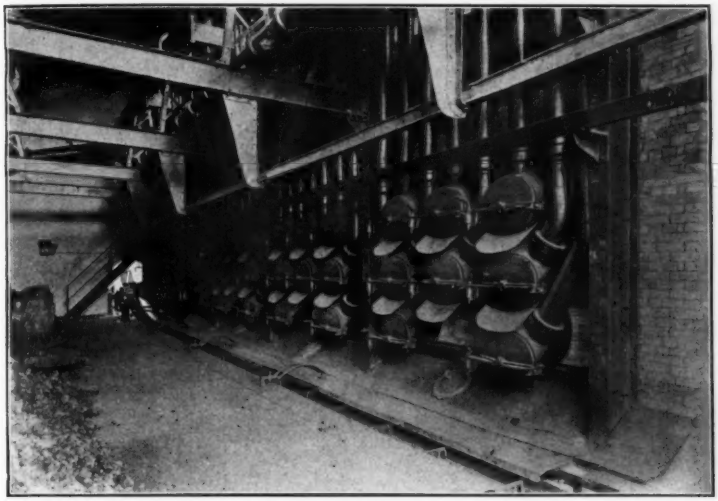


RUBBER BELT CONVEYOR AND MOVABLE THROW-OFF CARRIAGE FOR DISCHARGING INTO ANY BIN.
Graham, Morton & Co., Leeds.

S, and as they have opposite directions of rotation, power can be applied to drive the carrying wheels, from either of the pulleys, by use of spur and worm gearing. The reversal of the tripper at each end of its run can be made automatic, by means of levers carrying a falling weight, which reverses the train of gears.

Passing to the use of conveying appliances at blast furnaces, it may be remarked that some means of reducing manufacturing costs has long been needed. The hoisting arrangements for the ore and stone have, from time to time, been fully explained by contributors to this Magazine, but to my mind the mechanical means for making and loading pigs after the metal leaves the furnace deserve greater prominence than has generally been given to them. The Uehling casting machine (described elsewhere in this issue by Mr. Hatch), as is well-known, consists essentially of a very strongly built conveyor, the overlapping "buckets" of which are pig-iron moulds; these are passed in endless procession under the pouring spout, through a proper distance of cooling travel, and dumped into a tank where the solidified pigs are taken in turn by a plate conveyor to loading or storage. The significant point is not merely the cheapening of labour costs, but the complete removal of the limits to blast-furnace production which formerly lay in the limited capacity of the sand bed. The first successful Uehling plant in Great Britain was put down a year or more ago, at the works of Bolckow, Vaughan & Co., Middlesbrough, and has a capacity of 1,200 tons a day.

PART OF THE COAL AND ASH-CONVEYING PLANT, FRICKLEY COLLIERY OF THE CARLTON MAIN COLLIERY CO., LTD.
Installed by Ed. Bennis & Co., Little Hutton, Bolton.



RETORT BENCH AND HOT-COKE CONVEYOR IN A MODERN GAS WORKS.

The discharging end of inclined retorts, Shrewsbury Gas Works. The coke slides out when the retort doors are opened and is carried away by the conveyor. Erected by R. Dempster & Sons, Ltd., on Broadhead's patents.

In dealing with the coke pushed out by ram from coking ovens, and transporting it to trucks, what used to be a difficulty has, after much experiment, at length been overcome. I refer to the excessive wear and tear, not to speak of breakdowns, inseparable from the conveyors at first used. These, more often than not, were designed with insufficient regard for the difficulties consequent upon handling material possessing the wearing properties of either metallurgic or gas coke. Some years ago, Mr. Forgie, of William Baird and Company, took the matter in hand and designed a conveyor which Kesson & Campbell made for his company. This consisted of a traveling tray belt of iron plates, mounted on a single chain of massive proportions, to which were attached, at about 3-feet pitch, spindles for receiving at each end the rollers for carrying the moving trays. These ran on ordinary rail metals, of which there were four strands. The return belt passed underneath the loaded one, and between the two there was an obliquely set plate for directing, to the side of conveyor, the surplus water used in quenching the coke as it travelled on the conveyor to the railway trucks.

Steel-works managers, generally speaking, appear to be convinced that the wear on conveyors handling coke is so great that these mechanical appliances are not suited to the pur-

pose. Such doubts indicate absence of study of the latest practice in gas works. There is, as a matter of fact, scarcely a gas works of any consequence where coke conveyors are not used for dealing with the products of partial distillation from the retorts, and the patents concerning such conveyors taken out during the last ten years would cover pages of the Patent-Office journal. The conditions at gas

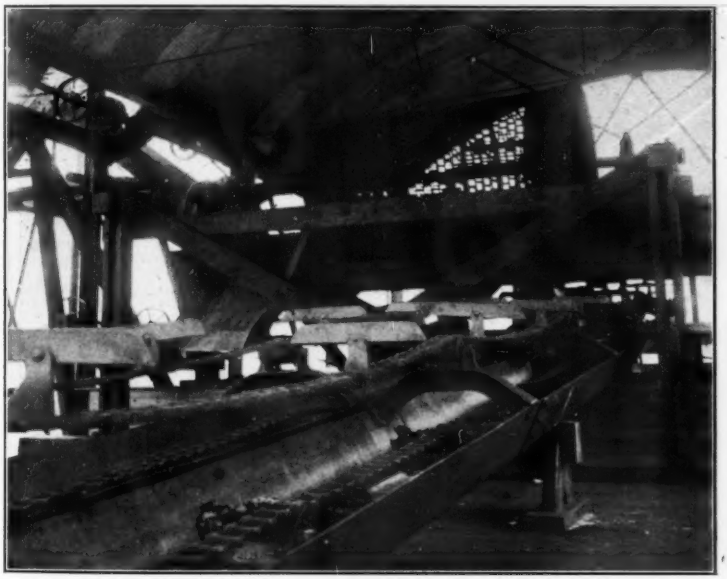
FOUR HOT-COKE CONVEYORS AND ONE CROSS CONVEYOR FOR FEEDING CRANE, BIRMINGHAM GAS WORKS.

The crane dumps onto bar screens for loading the coke into trucks or barges. Little's patents.

works are more arduous and exacting than at coke ovens, for the work is practically continuous, and as the coke must be removed in a hot state the conveyor must do this without reducing the size or making breeze.

British gas works are certainly far ahead of those of any other country in the application of mechanical transport appliances, and it is interesting to note that Mr. W. H. Bradley, of the Consolidated Gas Co., of New York, after a trip round the world, decided to follow British methods on his new works at Long Island, where inclined retorts are now being built. Retorts on this principle are set at an angle of 32 degrees, and are charged by gravity from measuring or weighing boxes, situated under longtitudinal coal hoppers, fed by conveyors receiving coal from stores through the elevator. When the gas in extracted, the door on the lower end of the retort is opened and the coke slides out into the conveyors.

Another good example of conveying machines is found in the application of an endless steel-tray conveyor in a machine shop, for the purpose of transferring the chips and cuttings from machine tools to the scrap heap. There is no limit to the length of such a conveyor or the number of machines it will serve; and the taking away of the scrap can be continuous or intermittent, as may be found more suitable. The principle can be applied to the handling of the products as well as the refuse, provided there is a sufficient number of machines at work on one article; and if there is a large number of these automatics in operation on, say, six different sizes or shapes, it is not difficult to arrange for each article being kept separate on the conveyor and at the point of discharge. These steel-tray conveyors are often used to transport coke to the producers in a water-gas house and generally for handling any gritty or viscous material. At chemical works,



INTERIOR OF A COKE WASHERY INSTALLED BY THE HARDY PATENT PICK CO., LTD., SHEFFIELD.

large pieces of phosphate rock are first unloaded into elevators and afterwards distributed to the large stores, a good example of this kind of plant being at the Wigg Works of the United Alkali Company. Here also there are additional conveyors and elevators for feeding the rock from stores to crushers, screens, etc., thus dispensing with barrows, hoists, and the army of labourers formerly required.

Ropeways form an entirely different class of transporter to the endless-chain conveyors previously dealt with, and their province is with outside and long-distance operations, rather than in workshops and warehouses.

Valuable as conveyors are as a means of saving labour, it must be remembered that the usefulness of these appliances does not end at this point. There are many cases where other important considerations arise, such, for instance, as the necessity for rapidity in handling, in order to keep the output sufficiently high, and the fixed dead charges per ton low. Then, again, where labourers are scarce or unsatisfactory much may be done to relieve the situation by putting down

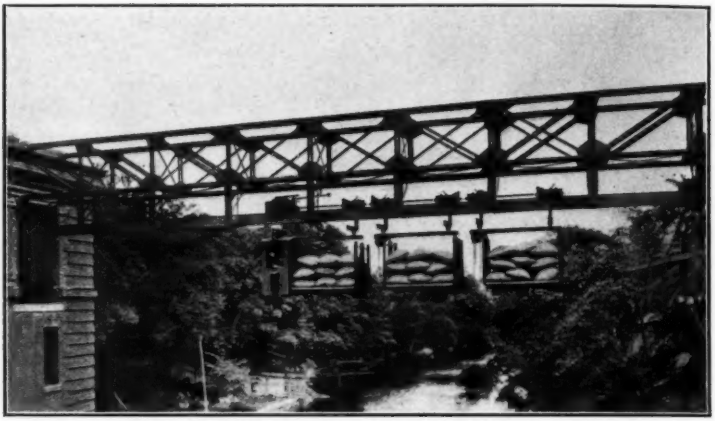
DOUBLE-STRAND ROLLER-TYPE CONVEYOR, 140 FEET LONG, 15 INCHES WIDE, 30 TONS PER HOUR CAPACITY.
By Blake, Barclay & Co., Greenock.

conveyors. To cite another instance, there are many kinds of machines which require provision for dealing with large quantities of material, in continuous loads over a long period. Take a crusher, tube-mill, stamp, or grinding-mill plant. Each crusher may have a capacity so great that hand labour, or mechanical appliances handling large loads irregularly, prove utterly inadequate for feeding. For this relief may be found in the adoption of a mechanical method of transport, which embodies the principle of continuous supply of small quantities at high speed, and this can be applied both for feeding to and removing from the machines. Perhaps of even greater benefit is the spreading of work over a long period, in order to get

COKE CONVEYOR WITH SCREENING, SORTING, AND RAILWAY-WAGON LOADING PLANT. Installed on the De Brouwer patents at Albion St. Gas Works, Salford, by W. J. Jenkins & Co., Ltd., Retford.

accumulated power from small machines. This is found practicable in loading hoppers which require to be quickly emptied at stated periods, and as an example we may take a plant for loading minerals or materials into ships where expedition is required, as in fact on a tidal river where the difference in levels precludes vessels from approaching the wharf except at high-water time. A small plant working over the twelve hours would put into the hopper sufficient material to fill a large hold, and on a wide river or flat coast the ships could be loaded and sent off on the same tide on which they came in.

A ROPEWAY FOR CARRYING "PADDY," AT WORK IN CHINA.
Length 620 ft.; capacity 30 tons or 420 bags of paddy per hour; twelve ropeway grips; lattice steel towers 35, 32 and 25 ft. high; 4½ by 10 in. horizontal engine for driving. John M. Henderson & Co., Aberdeen.



TELPHERAGE SYSTEM, WALTER BAKER CHOCOLATE WORKS.
The line runs from the freight station along a river and into the mill. The telpher and two trailers handle bags of cocoa. United Telpherage Co.

The employment of labour-saving machinery will, in my opinion, become more and more general as manufacturers popularise the knowledge of its usefulness. Conveyor makers, heretofore, have surrounded their industry with artificial difficulties, forgetful of the fact that, advantageous as it may seem to keep secret from would-be competitors the result of accumulated experience, there is greater danger to themselves in leaving in ignorance the prospective purchasers.

Daniel Webster, lecturing in 1828 on the progress of the mechanical arts, eulogised the power of machinery in general, but in a manner which unconsciously particularised transport appliances. Although realising the illimitable possibilities discoverable by man, through the progressive improvement of his faculties, Webster could not "pierce the shades of dim futurity" and forecast the benefits beyond human measurement, which would result, in the short compass of a century, from human sagacity, stimulated by human wants, seizing on the natural assistance of mechanical power. Yet even in his day it was possible to draw a word picture such as this:—

> "Machinery is made to perform what has formerly been the toil of human hands, to an extent that astonishes the most sanguine, with a degree of power to which no number of human arms is equal, and with such precision and exactness as almost to suggest the motion of reason and intelligence in the machines themselves. It is on the rivers, it is on the highways, and exerts itself along the courses of land conveyance; it is at the bottom of mines, it is in the mill and in the workshops of the trades. It excavates, it carries, it draws, it lifts. It seems to say to man —'Leave off your manual labour, give over your bodily toil; bestow but your skill and reason to the direction of my power, and I will bear the toil.'"

Marion Steam Shovels at Work in Burt Mine, Kibling, Minn.

MECHANICAL HANDLING IN THE MANUFACTURE OF IRON AND STEEL.

By James N. Hatch.

It was pointed out in the introduction to Mr. Norris' article that any economies in the production of coal must ultimately be reflected in the reduction of all power costs based upon coal-using. So any economies in the manufacture of iron and steel must affect the material cost of almost all engineering construction, for these are the almost universal structural materials of the day. And as a concrete demonstration of labor-saving appliances in mining and mechanical transport, Mr. Hatch's subject affords the most majestic and impressive examples to be found in the world.—THE EDITORS.

THE steel industry in the United States, which has now become so gigantic that national prosperity seems to be in a large measure dependent upon it, has had its birth and growth in the last forty years. Yet so great and so rapid has been this growth that the annual consumption of the country is now nearly 10,000,000 tons—an amount which, if rolled into a single 50-pound railroad rail, would make a rail long enough to reach from Pittsburg to the moon, or enough for a railroad track to the moon every second year.

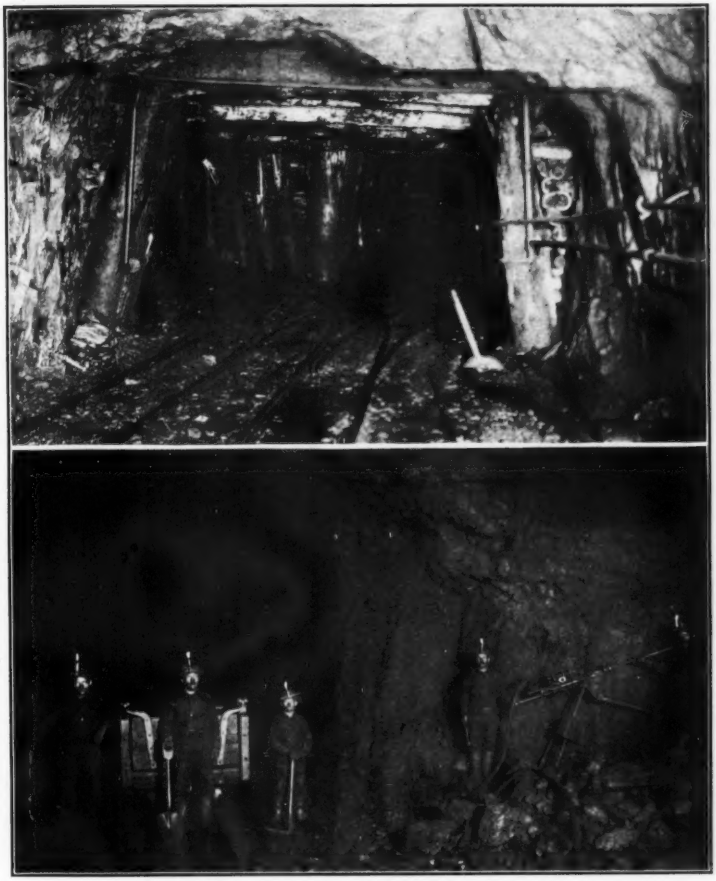
To gather together the ingredients and to manufacture this amount of steel is an enterprise of such gigantic proportions as to be almost beyond comprehension. And when is added to this the distribution of the finished material over the entire civilized world, the fabulous stories of the "Arabian Nights" fade into insignificance. The ingredients used for making all of the iron and steel used in the United States each year will easily aggregate 80,000,000 tons. These ingredients are moved on an average of 400 or 500 miles. This means that

if the whole population of the United States were set at the task by hand labor, each individual would have to transport one ton of material 400 or 500 miles per year, or over a mile per day, to do his part in collecting the ingredients for supplying the nation's iron and steel. This exemplifies what an enormous part machinery must play in this enterprise.

An article on the subject of steel making in the United States naturally divides itself into three somewhat distinct parts; (1) the mining of the ore; (2) the transportation to the furnaces, and (3) the convertion of the ore into steel. A detailed account of the various processes used in any one of these branches would lead far beyond the scope of a magazine article, so only some of the more conspicuous points can be touched upon, such as will best connect the various links of a somewhat roughly forged chain of events through which our iron ore must pass.

The Lake Superior region really became a factor in the iron business in 1856, when the through shipment of ore by lake was begun. The few thousand tons that had been mined in that region prior to that were hardly significant, compared with later figures. At that time the annual consumption of domestic iron ore in the United States was about 1,600,000 tons, derived principally from Pennsylvania. Prior to 1854 it is estimated there had been taken from Lake Superior mines about 75,000 tons of ore, the product having been worked up into pig iron in the old charcoal furnaces and catalan forges near the mines. A trial lot of ore had been sent to Pittsburg and another lot to New Castle a year or so earlier than this, but the portage around the Sault Ste. Marie Falls (which required loading and unloading several times) made the freight rates so excessive as to discourage the movement in large quantities. In the summer of 1855 the first locks of the Sault were completed, and the movement of ore from the Lake Superior mines to the Lake Erie docks began in real earnest. The year 1856 really marks the beginning of the line of lake shipment, and the output from the Superior region, which was then confined to the Marquette Range, was for that year 6,790 tons. The ore was transported from the mines to the docks by teams of mules over the new plank road which had been completed the previous year.

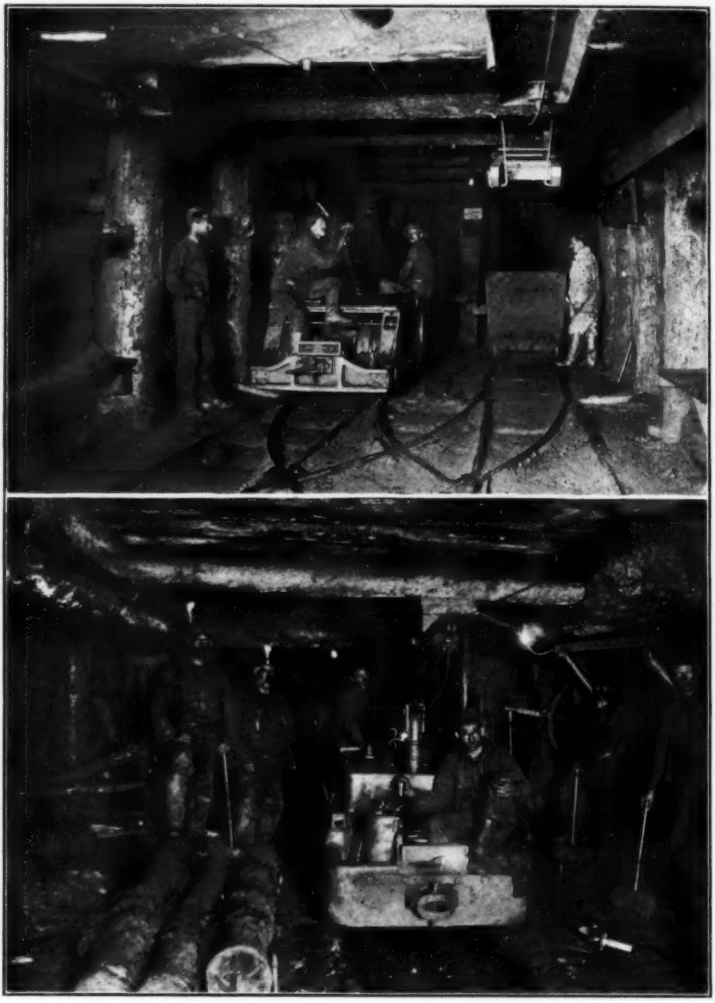
At that time only deep mining in hard ore was carried on, and only the crudest machinery was employed. The soft hematite ores which were found upon the surface of the ground were supposed to be valueless. A shaft was sunk through the top earth till the vein of ore was struck, or the ore was reached by horizontal drifts. The ore was loosened up with picks and shovel, thrown into buckets, and



UNDERGROUND WORK IN LAKE SUPERIOR IRON MINES.
The lower view is in a hard-ore mine—the Cliff shaft of the Cleveland Cliffs Iron Co. The upper one is in a soft-ore mine.

hoisted to the surface by windlasses turned by hand, or with the use of horse whims. On the horizontal drifts carts and wheelbarrows were used to bring the ore to the surface. In 1857 the first railroad for carrying ore was completed from Marquette to the adjacent mines, and the output was quadrupled.

Power drills driven by steam or compressed air were introduced in 1878, and the use of tram cars was begun in 1880. Since then the improvement of mining machinery and the invention of more effective explosives has kept pace with the other improvements. As the im-



ELECTRIC HAULAGE IN THE LAKE SUPERIOR IRON MINES.

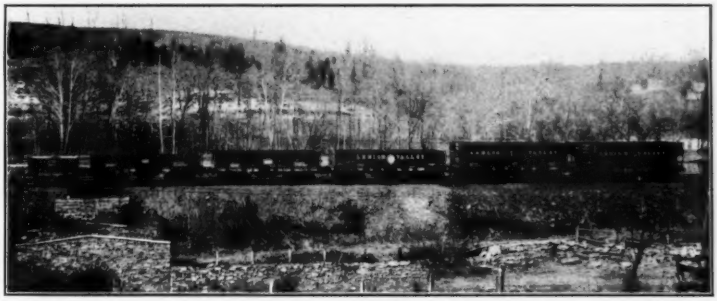
The upper picture is taken in the Lake Angeline Mines; the lower is in the Cleveland Cliff mines, near Ishpeming, Mich.

provement in machinery has moved up the cost of ore production has moved down, so that now ore can be produced at the mouth of the mine ready for shipment at 70 cents per ton, where it would have cost $3.00 or $4.00 per ton fifty years ago. The use of electric, hydraulic,

and pneumatic machinery, of cable and electric tramways and hoists, has so far improved conditions that one man will now do the work that formerly would have required a score or more.

Mining is carried on in the Superior region under two general systems—surface mining and deep mining—somewhat more than one half of the output still being taken from shafts sunk to a depth of 1,000 or 1,500 feet.

The modern methods of deep mining have been attained by gradual stages; but in surface mining, the use of the steam shovel by which nearly one-half of the output of the Superior region is now obtained has sprung up as if in a day. A steam shovel taking up 5 or 6 tons at each scoop can be operated with three or four men, and will mine and load 5,000 or 6,000 tons of ore per day, or about 150 to 200 carloads. Hand shoveling of the same amount of ore would require the services of 75 to 100 men. As fast as the cars are loaded they are drawn out of the ore pit and made up into trains of 40 or 50 cars each, ready to be taken to the ore dock.



1860	1875	1888	1890	1895	1900
6 tons	20 tons	25 tons	30 tons	40 tons	50 tons

THE EVOLUTION OF THE ORE AND COAL CAR.

Some idea of the magnitude of the iron-ore mining industry in the Superior region may be gained from the fact that the annual excavation of ore, not including the refuse incidentally removed in stripping, is equivalent to 50 acres dug to the depth of 100 feet. When loaded on cars it represents a train 5,000 miles long. The illustrations show some of the great craters left where mining has been carried on.

When the ore has been mined and loaded on the cars it is ready to start on its journey of 1,000 miles or more across land and sea to the furnaces. The first link in this chain is the ore-carrying train from the mines to the ore docks. The distance varies from only a few

miles to something over 100 miles. The great locomotives that haul these long trains of ore cars are ponderous machines and have played an important part in ore transportation, but do not differ widely from hundreds of others. The unloading of these trains at the docks, however, offers some novel features. The railway tracks from the mines lead out upon the storage docks into which the ore is to be dumped. Each car is first stopped upon a track scale and the weight of the cargo obtained. The train is then hauled out upon the docks, and stopped over the ore pockets. Here the bottom of the car is opened. At this point, however, a strange thing occurs. The ore although permitted to run out, does not do so. The fact is that after the ore has been jolted down by its ride from the mines, it packs in the car so tight that it is only by much prodding and punching, requiring the work of a dozen men ten or fifteen minutes, that it can be induced to flow out through the open bottom of the car. In this respect the ore docks are not up to date, as the cars could be unloaded much more rapidly and at considerably less cost by a car-unloading machine such as will be shown further on.

There are at various harbors along Lake Superior and Lake Michigan between twenty-five and thirty of these ore docks, with an aggregate length of nearly six miles and a total storage capacity of nearly 1,000,000 tons. Some single docks are over 2,000 feet long and can accommodate four or five vessels at a time. The total cost of construction has been over $7,000,000. At first thought it might seem that the interest on the great cost of these docks would go far toward offsetting the possible saving; but when it is remembered that with these improved methods a dozen vessels can load and a dozen trains unload in the same space and in the same time required for one under the old *règime,* it will readily be seen that there is actually a saving per ton of ore moved.

The loading of an 800-ton vessel of the 50's was a stupendous task, and the hand shoveling, wheel-barrow movement, and hand dumping, cost not less than 40 cents a ton. At the present time, the ore could be mined, transported to the dock, and loaded, for little more than that. It is a very common thing for a 6,000 or 7,000-ton vessel to load at one of these modern docks in two or three hours. The dock at Duluth, of the Duluth, Missabi and Northern Railway Company, made a loading record in June, 1901, which had never before been approached on the lakes—64,000 tons of ore in 24 hours, loaded into fourteen large vessels of about 4,500 gross tons cargo.. This would be equivalent to a season's movement of 13,000,000 tons. During the present summer the Augustus B. Wolvin, the largest boat on the

CONNEAUT DOCKS; SHOWING ORE VESSELS CROWDED IN, WAITING TO BE UNLOADED.

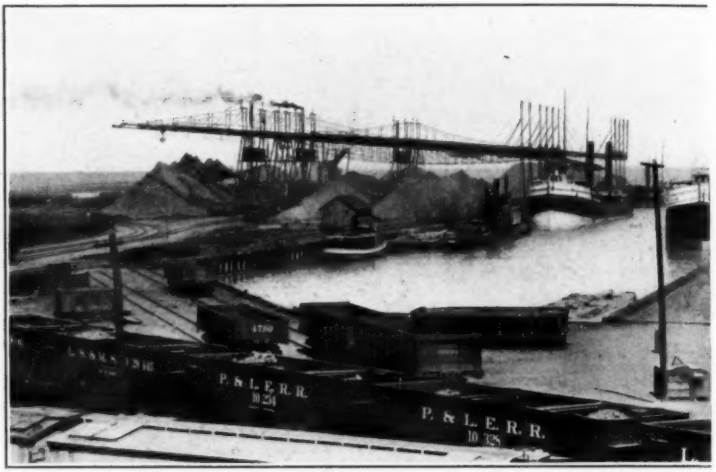
lakes, was loaded from the Great Northern Railway dock at Allouez according to the following schedule:—

Boat arrived at dock	2:45 P. M.
Started to load	4:16 "
Finished loading 9,000 tons	4:50 "
Shifted to complete cargo	45 minutes.
Loaded complete (12,245 tons)	5:45 P. M.
Total time at dock	3 hours.
Total time loading	1 hr. 29 min.

These figures are of course record-breaking, but serve well to show the possibilities.

There are at present several hundred ore-carrying vessels on the Great Lakes, capable of moving during the season of open navigation fully 30,000,000 tons of ore. The vessels vary in carrying capacity from 2,000 to 12,500 tons burden. It hardly need be explained that the smaller ones are in most instances those of the older type which are not yet worn out. The 12,500-ton vessel represents the latest type of ore carrier. They are 550 feet in length and of about 15,000-tons displacement. These vessels are made entirely of steel, and have a horizontal steel floor near the bottom, on which the ore is carried. Below this floor are the compartments for water ballast.

During the shipping season of seven or eight months a vessel will make about twenty round trips, or a trip in ten or twelve days. Many



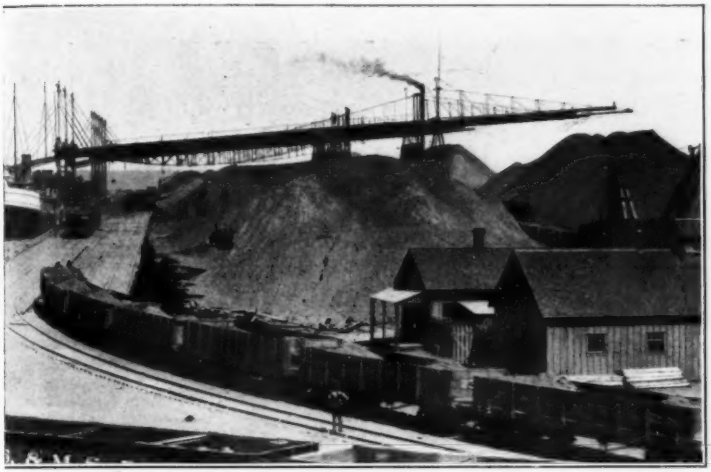
A PANORAMIC VIEW OF THE ASHTABULA, OHIO, ORE DOCKS.

of the newer vessels are designed for towing barges. With this arrangement one of the later style of vessels will tow two large steel barges at a speed of 11 miles per hour, moving an aggregate cargo of 20,000 tons of ore. This constitutes a saving in power, capital invested, and wages paid to seamen.

It is interesting to note * the great reduction in freight rates that the improvement in vessels has made possible—a reduction from $3.00 per ton to 60 cents per ton. These are the transportation charges from upper lake port to lower lake port, and do not include loading or unloading. A reduction of 80 per cent. seems almost phenomenal, and yet it is said that owing to increased draft, larger vessels, more economic engines, prompt loading and discharging, etc., the transportation companies earn as much on the long hauls at this low rate as they formerly earned with the higher rates. Another interesting point is that all this reduction has been made without any reduction in wages; for the fact is that seamen's wages in this class of business have been materially increased in the last twenty or thirty years.

There are a number of very efficient coal-loading docks at the lower lake ports, and a vast number of coal unloading docks at Duluth and elsewhere on Lake Superior, so that many of the vessels which come down the lakes loaded with ore are able to return with a cargo of coal. This is equivalent to another saving in freight on ore. The

* A table giving these carrying charges for every year from 1854 to 1900 was published in connection with an article by Mr. Hatch in THE ENGINEERING MAGAZINE for August, 1901. Since that time the rates have been almost unchanged.



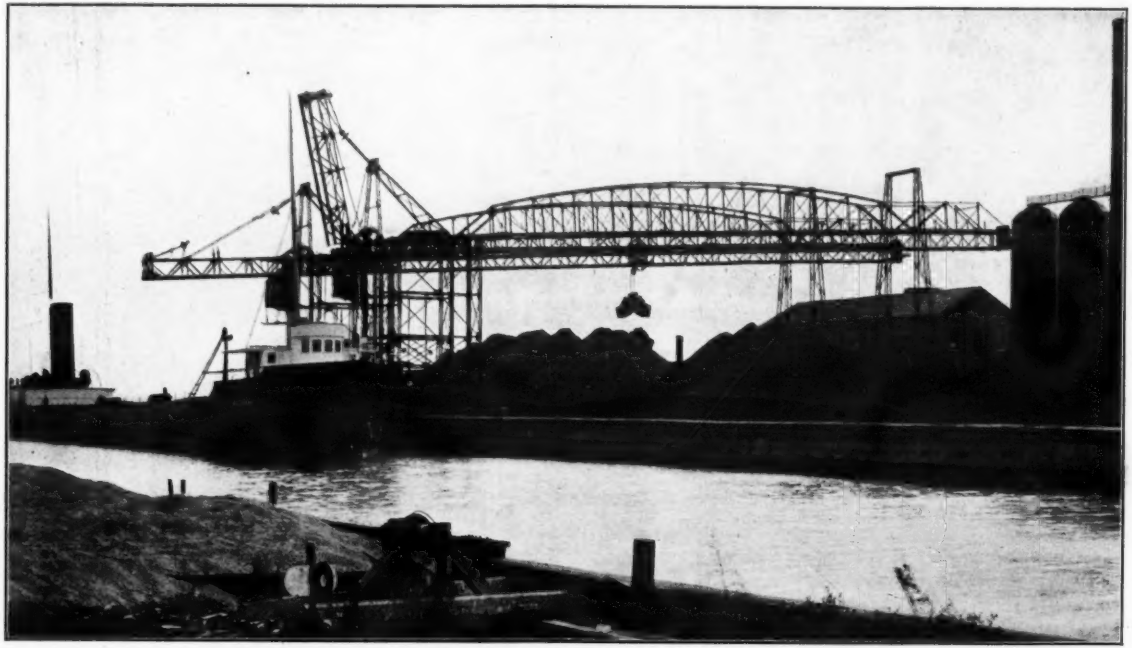
THE ASHTABULA ORE DOCKS. SHOWING BROWN HOISTING MACHINERY.

loading and unloading of coal can be performed fully as rapidly as that of ore.

Among all the docks on the lakes, that of the United States Steel Corporation, at Conneaut, Ohio, is the most interesting. This is one of the newest docks on the Lake Erie shore and is equipped with the most modern and most efficient unloading machinery. It has been gaining more rapidly in receipts than any of the other docks, rising from 1,404,169 tons in 1898 to 3,903,937 tons in 1903, and is destined in a few years to be the greatest of all.

The highly specialized machinery developed for unloading vessels and trains is noteworthy because of the very important part it plays in the production of steel. The problem of unloading the ore from the vessels and of loading into cars for shipment inland was one that could not be solved by a gradual improvement of the older methods, as was the case with mining, loading, and shipping machinery; it required the invention of something entirely new and untried. Very naturally, therefore, unloading machinery was of later introduction, and it may be said even now that this branch of machinery is only in the earlier stages of development. Because it was thus the product of a special invention, to meet a special requirement, these machines exhibit a great variety, representing the many minds of many men.

The first permanent improvement was in the introduction of a cantilever crane, extending from a point upon the wharf out over the

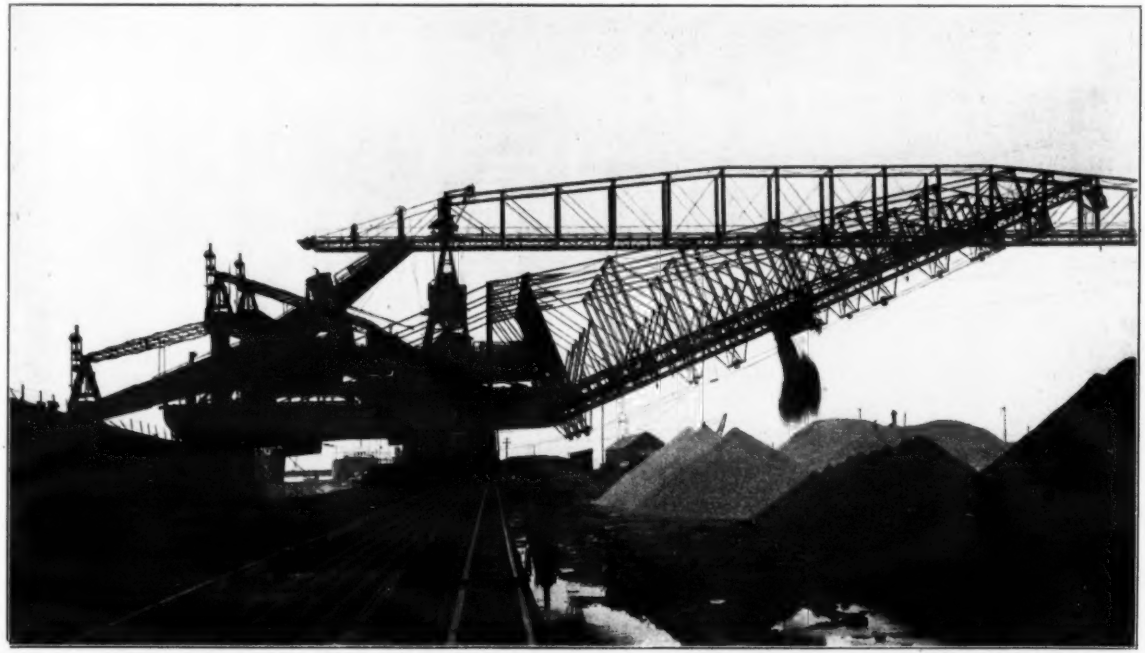


TWO ORE BRIDGES AT THE DETROIT IRON & STEEL COMPANY'S PLANT, DELRAY, MICH.

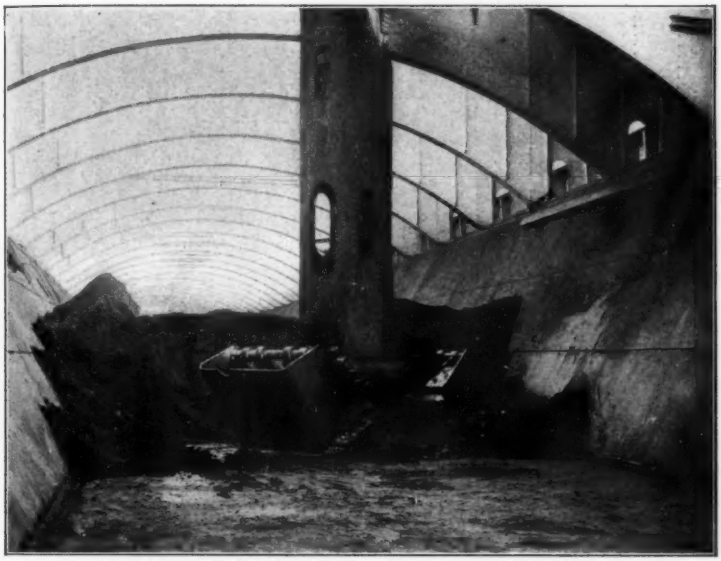
These are the Hulett patent ore bridges, equipped with Hulett excavating buckets, and are used for unloading ore from vessels to stockpiles, and also for transferring from the stockpiles to bins, over which the cantilevers of the bridges extend. Wellman-Seaver-Morgan Co.

ship. Upon this cantilever a small trolley was drawn back and forth by means of a rope from a hoisting engine. From this trolley a hoist rope raised and lowered the bucket. In this way a bucket carrying a ton or more of ore could be used, instead of a bucket of a few hundred pounds capacity. The buckets, though still filled by hand, could be handled much more rapidly than the smaller ones had been, and the cantilever was long enough and high enough to allow the cars to be so placed beneath it that the buckets could be dumped directly into them. This style of machine was the pioneer mechanical unloader and was a marvel for speed when compared with any previous methods. Unloading that had been accomplished by hand at a cost of 40 or 50 cents per ton could be done with the new machinery at 15 to 18 cents per ton. But the factor that was of prime importance was the possibility, with five or six of these machines, of unloading an ordinary vessel in 10 or 12 hours—an absolute impossibility under the old method.

This class of mechanical unloading machinery was introduced about 1881 and soon proved a tremendous factor in the steel-making industry. Not long after these first machines proved their efficiency, a variety of different appliances were constructed on practically the same lines. In a very few years all the important ore docks were equipped. In fact, it has been only within the last five or six years that anything better than the bridge tramway, about as described above, has been brought out. A number of years ago a bucket had been constructed which would automatically fill itself with coal or gravel or sand. This was tried on ore, as of course it was a source of considerable saving of labor, but was found to be a failure. The ore was so heavy and compact the bucket could not be made to dig into it; and although many attempts were made, by various companies, to construct a bucket that would work on ore, it required several years to accomplish the feat, and the inventors who finally solved the problem were not those who had been pioneers in the field, but men who were comparitively little known in this line of invention. These automatic grabs, of which several types are now manufactured, almost entirely dispense with hand shoveling and have again made a great saving in the cost of unloading, reducing the cost from 15 to 18 cents per ton to 5 or 6 cents per ton, according to some later records. In the Hulett unloader, as shown in an illustration, the bucket picks up 10 tons at a grab and each machine will unload 300 or 400 tons per hour. A record was recently published of a single machine unloading 681 tons in an hour, at the Conneaut docks. The steamship Augustus B. Wolvin (the same ship mentioned in connection with loading), was



THREE OF THE FIVE HULETT PATENT AUTOMATIC ORE UNLOADERS, LACKAWANNA STEEL COMPANY, BUFFALO, N. Y.
The unloader leg of the nearest machine is in the "down" position, at work in the hold of the vessel. In this plant, inclined cantilevers are used to convey the ore to the stockpiles. The unloader bucket dumps into hoppers, which discharge in turn into auxiliary bucket cars; these travel out over the cantilevers and empty their load at any desired point. One is shown just dumping. The bucket cars are automatic in movement, discharging at the desired point and returning, closed, under the hoppers for another load. Wellman-Seaver-Morgan Co.



HULETT UNLOADER, WORKING IN THE HOLD OF THE AUGUSTUS B. WOLVIN.

The bucket is of 10-gross-tons capacity, 18-feet total spread of opening; by telescopic extension, it can reach more than halfway from center to center of hatches. The leg travels lengthwise of the hatch, and revolves axially on trunnions in the walking beam. The operator located in the bucket leg, controlling all these motions, can thus reach practically all the cargo. Motion from hatch to hatch and operation of the bucket car are controlled by another operator. Wellman-Seaver-Morgan Co.

unloaded of 11,000 tons of ore at these docks, with the Hulett unloader, in 4½ hours. Half a dozen different kinds of unloading machines, with a total unloading capacity of over 25,000 tons per day, are installed at Conneaut. The docks at Cleveland, Ohio, are supplied with more than one hundred machines, with a total daily unloading capacity of 60,000 to 70,000 tons. With the new methods of unloading there is no necessity of any vessel remaining in harbor more than one day. At the Conneaut docks there is being used a floating fueller which fills the ship's bunker with coal while the ore is being discharged.

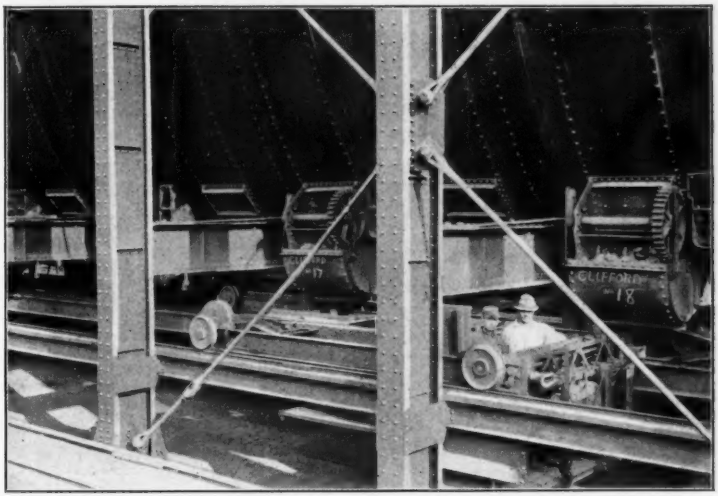
With most of these unloading machines the ore may either be dumped direct into cars beneath the machine, or carried back into stock piles for use when lake navigation is closed. As the shipping season is very short every effort is made to get the ore out of the vessel and upon the docks with all possible speed, thus enabling the ships to make the maximum number of voyages during the shipping season. Each day that a large vessel lies idle when navigation is open repre-

A MODERN AMERICAN BLAST-FURNACE PLANT, WITH ITS HANDLING MACHINERY.

The Carrie Furnaces, Carnegie Steel Co. The car-unloading machine, with an ore car standing on it, is shown on the right. Just to the left of this, between the railroad tracks, is the hopper and beneath it the 24,000-lb. buckets which are hoisted to the ore bridge overhead, carried out on it to the desired point, and dumped onto the stock piles. The furnace hoist and skip are seen in the left background. Brown Hoisting Machinery Co.

sents a loss to the owners of $250 to $300, to say nothing of interest on investment, insurance, etc.

The ore is taken from the unloading docks to the Pittsburg furnaces in long trains of 50-ton steel cars, drawn by some of the largest engines in the world. Upon arriving at the furnaces the question of getting these cars unloaded is the most important one. To accomplish this rapidly and economically, some of the larger furnaces are equipped with a car-unloading and ore-storage plant. With this arrangement the trains are broken up, and new trains are made up with the cars of ore and limestone alternating in the proportion in which those materials will be required at the furnace. A motor, placed be-

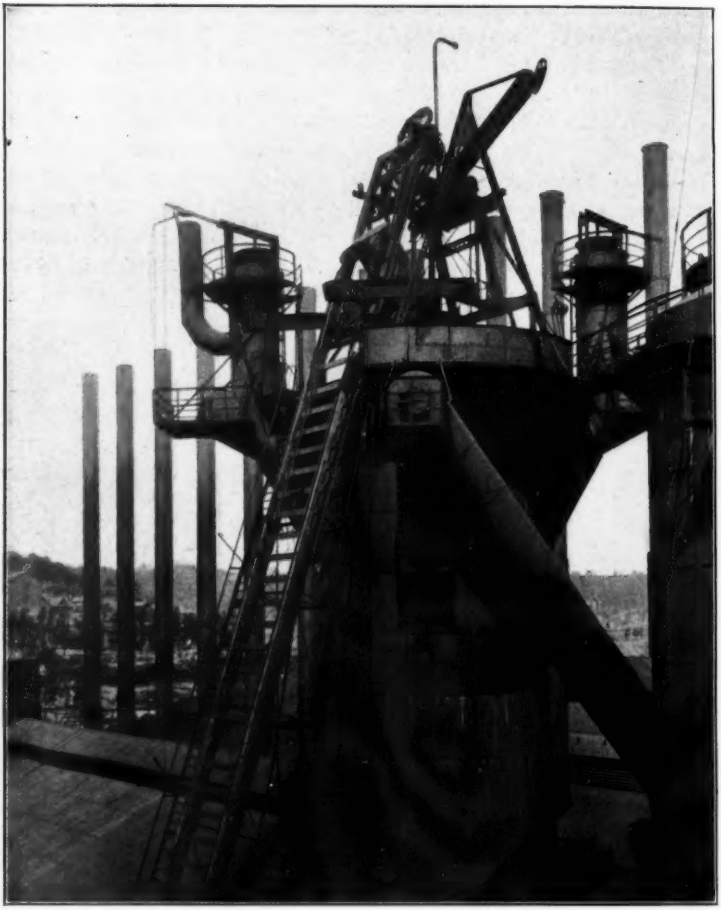


ORE-BIN GATES AND LARRIES, CLAIRTON STEEL CO., CLAIRTON, PA.

The larry transfers material from the bins to the furnace-hoist skip cars. A small motor on the larry drives a vertical shaft, provided with a universal joint and a male-and-female coupling which is thrown up into mesh by a foot lever. The upper portion of the coupling is fixed to the bin and operates the stationary mechanism operating the bin gates. The larry hopper is of 75-cu. ft. capacity, with bottom dump, operated by the larry man.

Brown Hoisting Machinery Co.

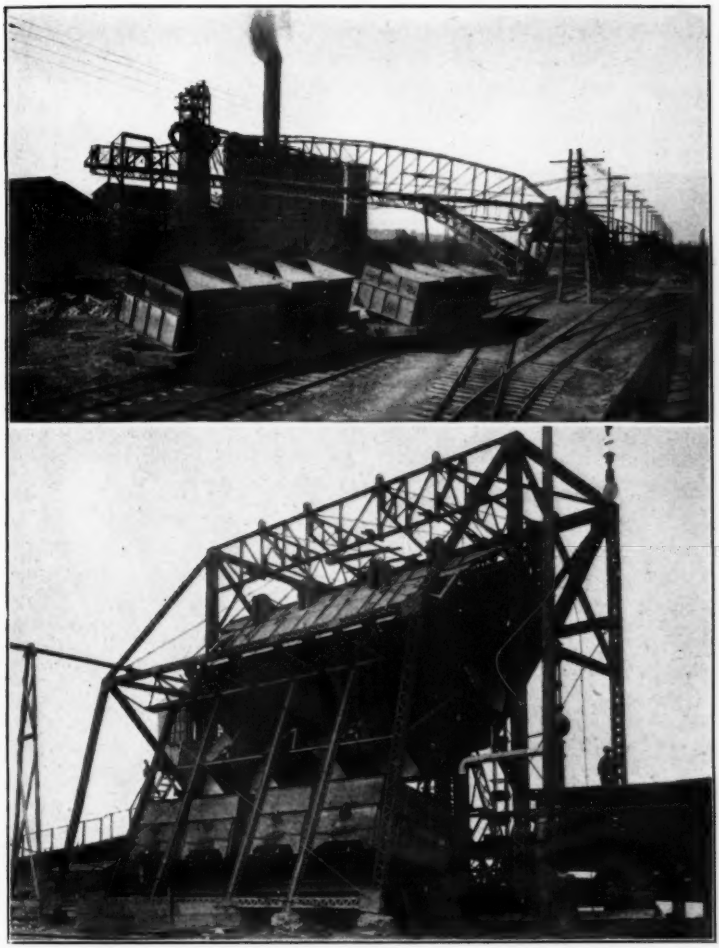
hind the string of cars, pushes them one at a time upon the unloading machine. When a car is upon the platform of this machine, clamps are dropped down over the sides, holding it down to the track. The operator, who is located in a house above, then starts in motion the machinery which picks up a section of the track, car, load and all, and turns it through nearly a semi-circle, pouring the ore out of the car into immense hopper bins. The car is then set back upon the tracks and the next loaded car, taking its place on the unloader, pushes the



A MODERN BLAST-FURNACE TOP AND HOIST.
La Belle Iron Works, Steubenville, Ohio; machinery installed by the Brown Hoisting Machinery Co.

empty car off the cradle. The car runs by gravity down from the unloader and into the storage yard for empties. One of these machines, recently installed for the Carnegie Steel Company, is guaranteed to handle three hundred cars per day of 10 hours. The ore after being dumped from the cars is carried back to the furnaces by means of an immense cantilever crane, which handles a bucket conveying 10 long tons, and has a trolley travel of 550 feet.

Estimated simply from an economic standpoint, the larger propor-

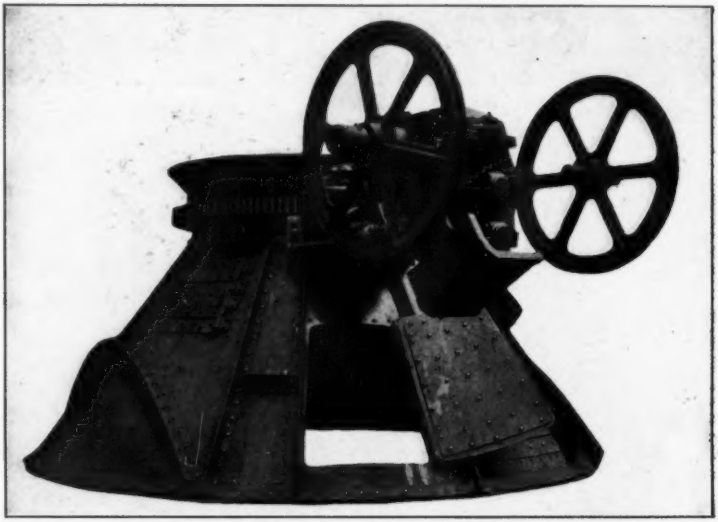


METHODS OF HANDLING ORE, OHIO STEEL COMPANY'S WORKS OF THE U. S. STEEL CORPORATION, YOUNGSTOWN, OHIO.

Railroad cars of ore are picked up bodily by the Hulett car dumper, as shown in the lower view, and dumped into "bridge cars," mounted on transfer cars. These latter are pushed by a locomotive into position opposite the bridge incline, shown in the upper view, and the bridge cars are successively pulled up by the haulage rope, run out over the stock pile, and side-dumped at any desired point. The dumping, righting, closing, and latching of the bridge cars is automatic; ore is taken from the stock piles by means of a drag bucket used in connection with the conveyor bridges, the cantilever of which extend over the furnace bins. The machinery is of Wellman-Seaver-Morgan installation.

tion of the actual cheapening of steel is due to the improvement in the methods of handling and shipping the heavy raw material. The actual improvement from a mechanical standpoint, however, is no less marked in the steelworks than elsewhere.

With the old methods, a swarm of men were seen around every open-mouthed furnace, sweating and tugging to move the great masses of hot metal from furnace to ingot molds, or along to the rolls. With the modern methods it is only occasionally a man can be discerned, perched in some out of the way place directing the operations of the ponderous machines. One of the first improvements that may be noted is that at the blast furnaces. Here, the ore, coke and lime-



STANDARD MECHANISM FOR DOUBLE-SKIP BLAST-FURNACE HOIST.
Brown Hoisting Machinery Co., Cleveland, Ohio.

stone are automatically weighed and mechanically transported to the furnace top; there they are automatically dumped in, landing upon a distributing bell which is kept revolving within the top of the furnace, thus insuring a thorough mixture of the mass. The great furnaces are being continually charged at the top and the molten metal is being continually drawn off at the bottom, without cessation day or night, winter or summer. In the best equipped modern plants the molten metal is taken direct from the blast furnace, in a hot-metal train, to the mixer, and from the mixer to the Bessemer converter or the open-hearth furnace. This saves much time and labor, and permits a considerable economy in retaining the original heat.

CRANE USED IN CONNECTION WITH PIG-IRON BREAKER.
Installed by the Brown Hoisting Machinery Co. for the Salem Iron Co., Leetonia, Ohio.

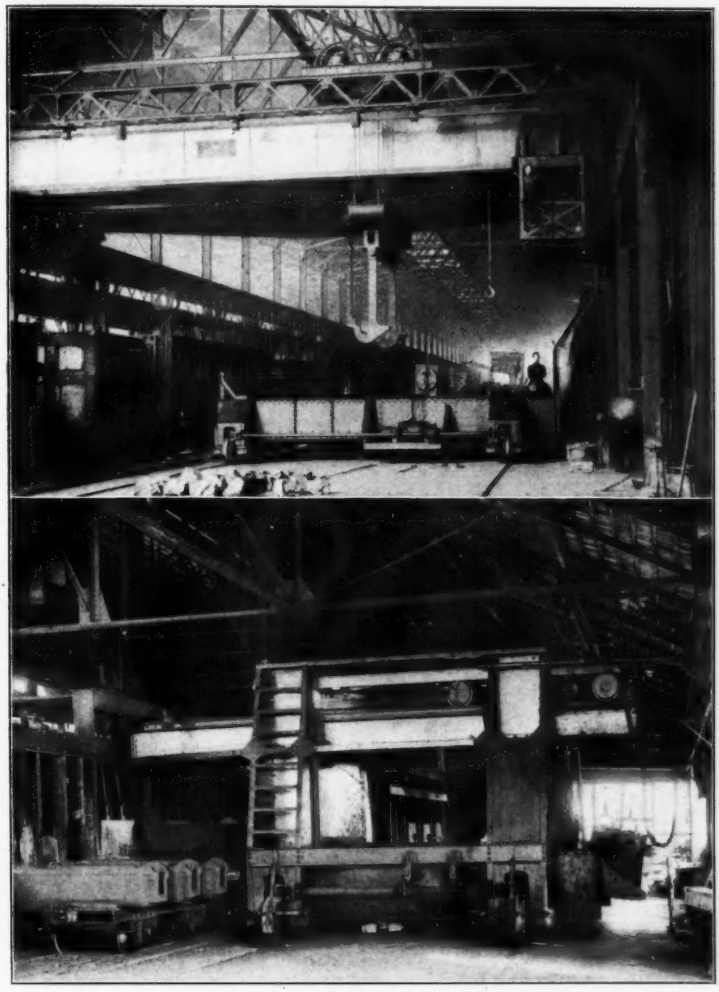
When for any reason it is still necessary to allow the metal to cool into pigs, the Uehling casting machine is used. This moves an endless chain of buckets, each with the capacity of one pig, beneath the ladle of molten metal from the furnace. The metal is then let out in a small stream, and the buckets are moved ahead as fast as filled, the stream running continuously. The chain of buckets then passes on through a tank of water, cooling the iron so that when the chain passes over the sprocket wheel and the buckets are turned up-side-down the pigs

A PIG-IRON BREAKER.
Brown Hoisting Machinery Co.; installed for the Salem Iron Co., Leetonia, Ohio.

10-TON LOCOMOTIVE CRANE WITH TWO-ROPE GRAB BUCKET, HANDLING IRON ORE.
Built by Brown Hoisting Machinery Co. for the National Tube Works, McKeesport, Pa.

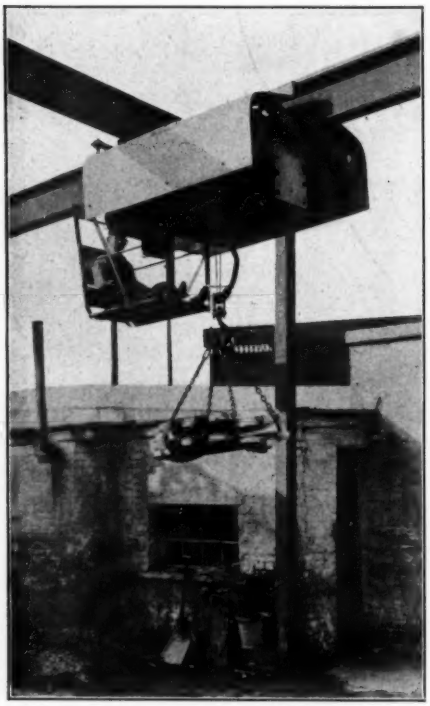
fall into a car placed to receive them. The pigs thus made are uniform in size and appear much cleaner and more business-like than those made in the old-fashioned way.

AN ENGLISH LOCOMOTIVE STEAM CRANE FOR USE IN THE STEEL WORKS.
Three pairs of engines. Lifts, slews, and travels with a load of 20 tons at 12-feet radius, 15 tons at 16 feet, and with lighter loads in proportion out to extreme lift of jib.
Marshall, Fleming & Jack, Motherwell.



CHARGING AND HANDLING MACHINERY FOR MODERN STEEL WORKS.
The upper view shows a 40-ton Wellman double-trolley ladle crane (10-ton auxiliary trolley) and Wellman low-type open-hearth charging machine, Sharon, Pa., works of the United States Steel Corporation. The lower picture shows a Wellman high-type open-hearth charging machine and charging boxes, Grand Crossing Tack Co., Hutchinson, Ill. The Wellman-Seaver-Morgan Co.

When the iron is delivered to the converter, either direct from the hot-metal train or after having been remelted in the cupola, it is ready to be converted into steel. The Bessemer converter, a gigantic ma-



ELECTRICAL JENNY, OR TRANSPORTER, FOR CARRYING PIG IRON.

Lifts 25 cwt. at 25 ft. per minute and travels with it at 250 ft. per minute. Jessop & Appleby Bros., Ltd., Leicester.

chine involving and requiring a host of auxiliary machines, did as much as any other one factor in the first development of the steel industry. The open-hearth furnace has since been perfected until it is about as economical, considering the class of ore that may be used.

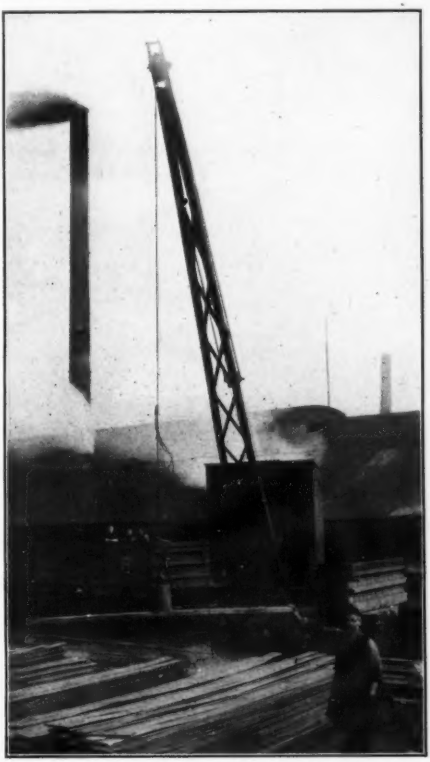
If the product is a bloom it passes to the mammoth bloom shear, where a knife falls and snips off a solid piece of metal 7-inches square as easily as a butcher would slice off a bologna. These machines have enabled the diversion elsewhere of the labor of scores of men, and each man replaced means a great saving in the cost of steel. There are still, however, many men needed, but it is the brain rather than the muscle now that is required. An expert must watch the converter and judge from the color of the flame when to start and when to stop. Another watches the furnace and decides when the metal is at proper heat for the rolls; but the actual lifting and pushing and turning and drawing of the great masses is done by the pulling of a lever or the changing of a switch from one side of a dial to another.

Perhaps no individual mill is more interesting or more complete than that where railroad rails are rolled. As was said, the molten metal is taken from the blast furnace to the converter, where it is a matter of only a few minutes to change it from pig iron to steel. The molten metal is then poured into ingot moulds and allowed to solidify. The moulds are then stripped off by machinery and the ingots taken to the "soaking pit," where they remain a few hours until they are

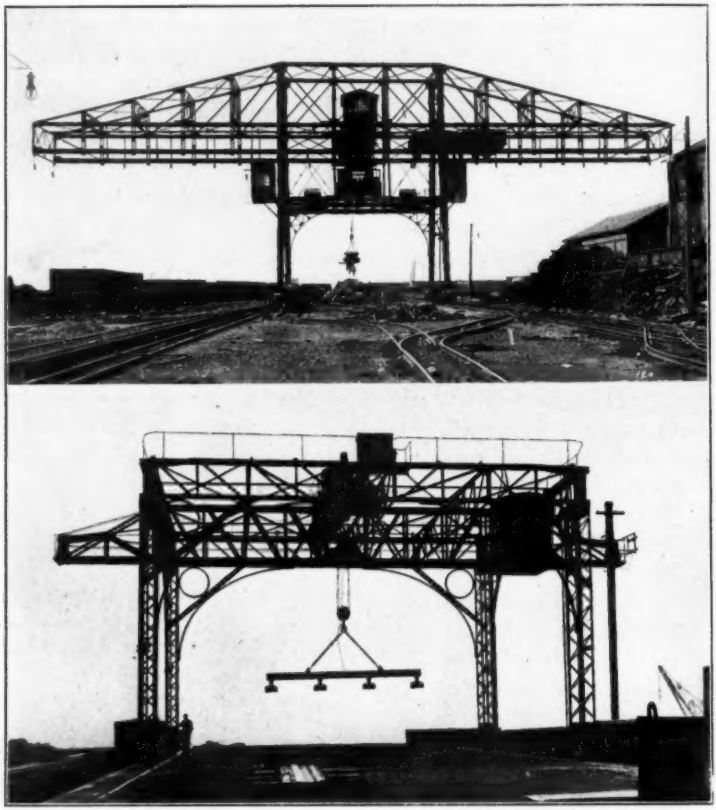
of equal temperature throughout; then they are ready for the blooming mill. In the blooming mill an ingot of steel 18-inches square and 7-feet long, weighing 3 tons, is rolled down to blooms 9-inches square and 15 feet long, by means of nine passes through the blooming rolls, accomplished in 45 seconds. This blooming process also tends to render the mass more constant throughout. The bloom is sheared up into shorter pieces, each of which has sufficient material for a 90-foot rail. These pieces are then taken, while still red hot, to the rail mill. Here each piece is sent back and forth through the rolls, each pass changing the square bloom into something more nearly resembling a rail. Finally the last pass gives the exact shape of the finished rail, and it is carried off to the hot saw. After leaving the rail rolls the rail goes to the hot saw where it is cut to exact length, with allowance for shrinkage. The rail is cambered, and then carried off into the piles ready for straightening, drilling, and inspection.

Beams, angles, z-bars, and all other commercial shapes are turned out in the same way. In material for bridges, buildings, etc., where a great variety of lengths are required, the exact length of each piece or of a number of pieces, is given to the man at the saw and he cuts the material up into the required lengths.

This is something of what is being accomplished in a modern steel plant; but improvements are still being multiplied in every department and no man can contemplate what wonders this will finally lead to. In the



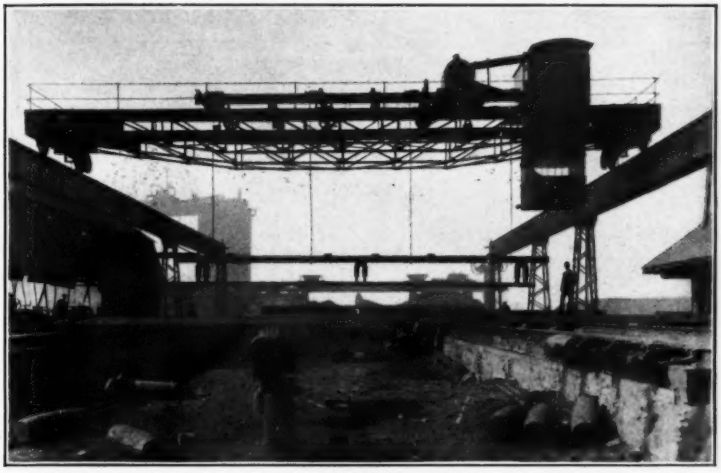
ELECTRIC PORTABLE CRANE, WITH LIFTING MAGNET FOR BILLETS, BARS, ETC.
Chambers, Scott & Co., Motherwell.



GANTRY CRANES FOR HANDLING MATERIALS IN THE STEEL WORKS.

The upper view shows a special three-trolley high-speed 10-ton gantry crane installed by the Wellman-Seaver-Morgan Co. for the Lackawanna Steel Co.; it is equipped with magnets for picking up pig and transferring it from large cars to cupola-charging cars, or to the stock pile. The lower figure is a 10-ton electric gantry crane with lifting magnets for the loading bank of D. Colville & Sons' steel and iron works, Motherwell; built by George Russell & Co., Ltd., Motherwell, Scotland.

last forty years the capacity of a blast furnace has been so improved that whereas a furnace of that time which could turn out 200 tons per month was considered a record breaker, now a single furnace will turn out 20,000 tons per month, or 200 tons in three or four hours. A single Bessemer converter can be charged and blown one hundred times in twenty-four hours, turning out 1,500 tons of finished steel; and a single train of three-high rolls will roll into commercial shape 3,000 tons of railroad rails in twenty-four hours, or about 65,000 tons per month.

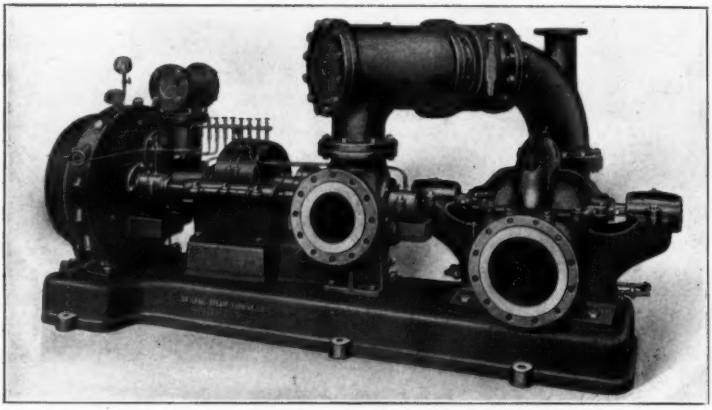


ELECTRICAL TRAVELING CRANE WITH LIFTING MAGNETS FOR HANDLING RAILS, GIRDERS, ETC.
Jessop & Appleby Bros., Ltd., Leicester.

When the steel leaves the rolling mills it has by no means passed out of the sphere of mechanical manipulation—in fact, each individual piece will probably pass through a score of different kinds of machines before it finally comes to rest in the finished structure of which it is destined to form a part. It is loaded into cars by a traveling crane which will pick up 15 or 20 tons at a load. From this crane there is suspended a carrying beam about 20 feet long. At each end of this carrying beam is attached an immense electric magnet. These magnets are lowered upon the flat plate, the current of electricity is turned on, and the magnets with the plate adhering are lifted up and carried to any desired position.

The structural shapes are sent through all kinds of intricate machines, where they are sawed, planed, punched, riveted, bent, and twisted into a thousand different forms. Machinery carries them from the mill to the structural shop, from the structural shop to the building site. With the aid of machinery these finished parts of the final structure are lifted into place and are riveted together.

By machinery, there has been in the last ten years 100,000,000 tons of iron ore taken from the Superior region alone, converted into articles of commercial usefulness, and distributed. By machinery the United States has become foremost in the production of pig iron, turning out 40 per cent. of the world's supply, and exceeding the production of Great Britain and Germany together.



HIGH-PRESSURE CENTRIFUGAL PUMP, DIRECT-DRIVEN BY STEAM TURBINE.
250 gallons per minute, 750-feet head. De Laval Steam Turbine Co., Trenton, N. J.

THE DEVELOPMENT OF POWER PUMPING MACHINERY.

By Wm. M. Barr.

In the following article Mr. Barr touches only upon the most important principles embodied in modern pumping machinery. In a succeeding number he will discuss more fully some of the mechanical applications of water power.—THE EDITORS.

THE earliest labor-saving devices included those for transporting water. The lifting of water to a level sufficient for the purpose of local irrigation was the simple beginning of the modern system of water supply. The work to be done in any hydraulic system is commonly that of lifting water from a lower to a higher level, as in pumping water out of a mine, or in utilizing a head of water to do useful work such as to drive a water wheel, or perform work which may be by pressure or by impulse in a closed hydraulic machine.

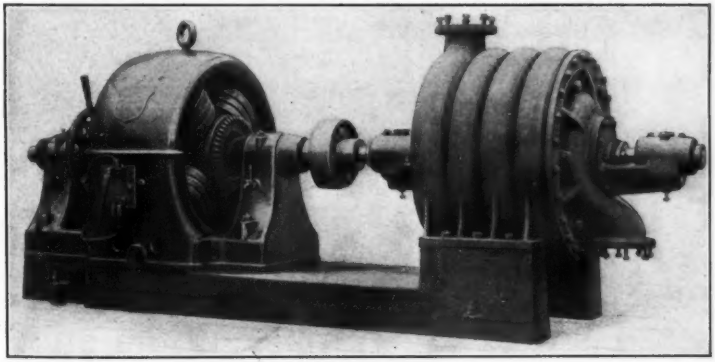
Water is valuable as a means of mechanical transport in its negative property of non-resistance to change of shape and its practical non-compressibility. The equivalent head to balance one atmosphere is about thirty-four feet, and, as water obeys the action of gravity with but little loss, pressure systems are easily established and economically maintained. Hydraulic machines are, therefore, exten-

sively used in engineering operations and rarely do they fail in meeting the exacting requirements in labor saving devices.

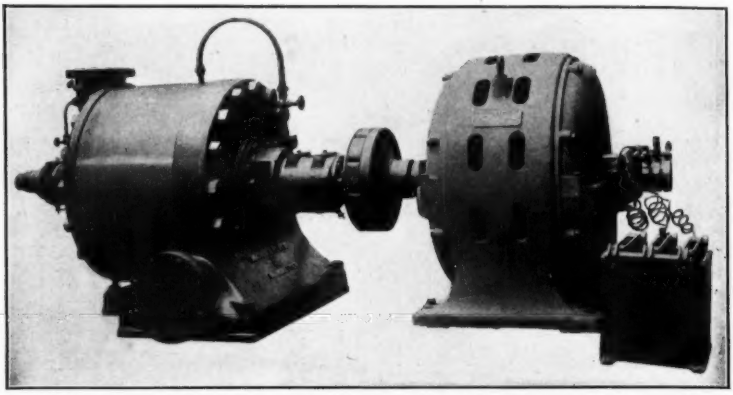
The ordinary lift and force pump enters so largely into present-day economics as to become an indispensable mechanism, whether operated by hand, by the action of the wind, or in the highly developed triple-expansion high-duty pumping engine.

Utilizing a stream of water so as to make it do useful work in the service of man has always engaged the mind of the thoughtful in all ages, but generation succeeded generation before it occurred to any one to construct the hydraulic ram, the essential principle of which is this:—a mass of water is allowed to flow freely through an inclined tube for a short time and thus acquire a certain velocity, and therefore energy, when its escape through the lower orifice is made suddenly to cease; the momentum of the moving mass then drives up a portion of its own volume to an elevation much higher than that from which it descended, the construction of the machine being such that the acquired energy is expended against the resistance of an air vessel which greatly assists in steadying the flow through the delivery pipe. This principle has advantages over a water wheel or a pump, because it accomplishes the desired object at one operation and in one machine. The efficiency of rams, in practice, varies between 30 and 80 per cent. of the power of the water, depending upon the speed at which it works, size and length of connections, and details of construction.

The centrifugal pump is commonly employed for raising large volumes of water under low lifts. In principle it is a turbine reversed,



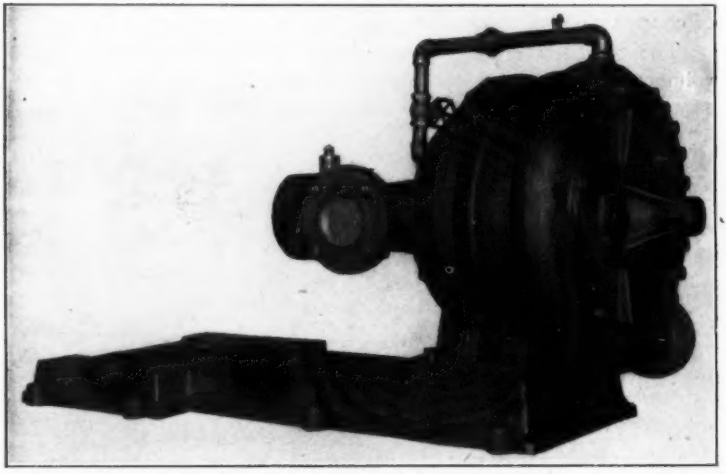
WORTHINGTON FOUR-STAGE TURBINE PUMP.
For a capacity of 700 gallons per minute against a head of 520 ft. Henry R. Worthington, New York.



THREE-STAGE COMPOUND CENTRIFUGAL PUMP FOR DIRECT CONNECTION TO ELECTRIC MOTOR.

To life 1,000 gals. per minute against a total head of 320 ft. Supplied to De Beers Consolidated Mines, Kimberley, by Mather & Platt, Ltd., Manchester.

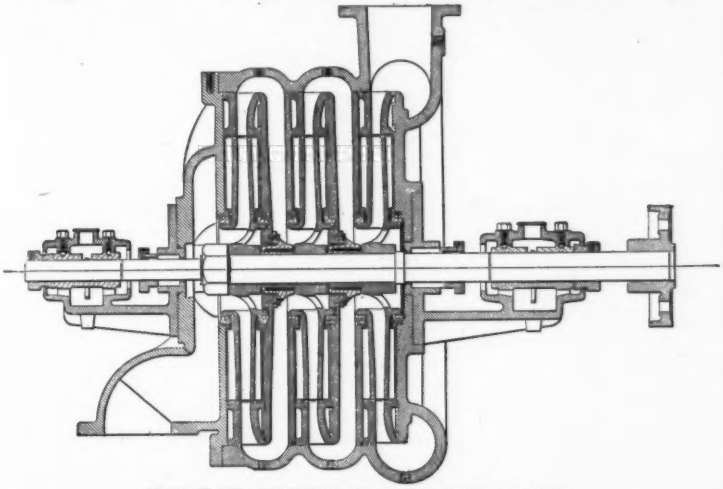
and, therefore, theoretically at least, should have the same efficiency as the turbine. Practically the efficiency is much lower, a good turbine converting about 80 per cent. of the potential energy of the water into useful work, whereas the effective work in lifting water by ordinary centrifugal pumps rarely exceeds 55 per cent. of the work applied. In the newer designs, the suggestion of Professor Thomson



FOUR-CHAMBER HIGH-LIFT CENTRIFUGAL PUMP, DIRECT-COUPLED TO POLYPHASE MOTOR.

Morris Machine Works, Baldwinsville, N. Y.

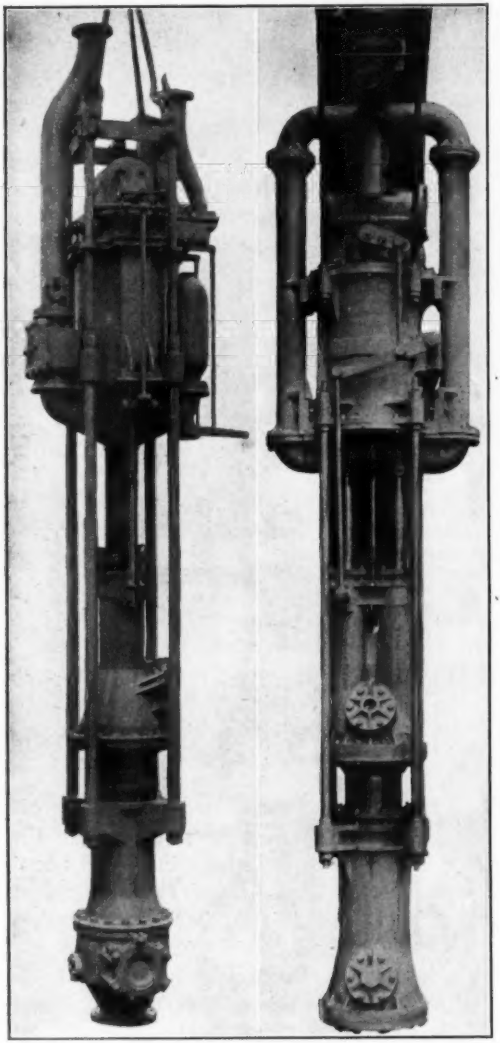
that the water leaving the wheel should be discharged into a chamber in which a free spiral vortex could be set up, thereby partly converting the kinetic energy of the water leaving the wheel into pressure head, has been generally adopted. In a pump in which four guide passages were used, the efficiency was found to be much greater than in the case of a free vortex delivery, converting from 70 to 75 per cent of the kinetic energy of the water leaving the wheel into pressure head at the discharge. The number of guide passages should not be less than four, and the areas at inlet should be such that the velocity of flow into the passages should be equal to the velocity of



SECTION OF WORTHINGTON MULTI-STAGE TURBINE.

discharge from the wheel, to avoid losses from sudden changes of velocity. Centrifugal pumps in multiple-stage construction can be adapted to any capacity and are now being built for heads up to 1,000 feet head or higher.

Vacuum pumps have long been used. In fact, they are among the earliest forms of steam pumping engines. The pulsometer is exceedingly simple, consisting of two bottle-shaped chambers joined together side by side, with tapering necks bent toward each other, and uniting in a common upright passage to which the steam pipe is attached. A valve is located at the bottom of each chamber; a small rolling valve is fitted at the top of the two chambers, closing one or the other, depending upon the outward flow of water from one chamber, or a vacuum in the other. Pulsometers will readily handle large



EXAMPLES OF SINKING PUMPS.

On the left, a double-plunger sinking pump by the Pulsometor Engineering Co., Ltd., Reading. On the right, a Denaby sinking pump by W. H. Bayley & Co., Ltd., Manchester.

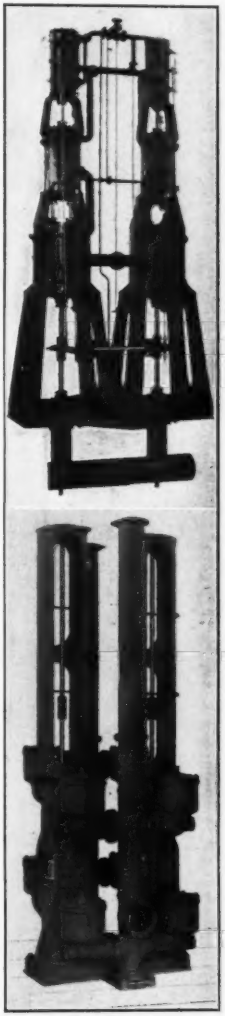
volumes of water, whether clear or muddy, but the duty is low, averaging about 7,500,000 foot pounds of work done per 1,000 pounds of steam used.

Raising water by compressed air has, under favorable conditions, certain advantages such as the absence of all moving parts common to ordinary pumps, but there must be an air compressor and an air receiver. The well having been piped for the delivery of water, a small pipe attached to the air-receiving tank is led to the well and thence downward to near the bottom, where it enters the water discharge pipe. The proportion of these two pipe diameters is commonly 1 to 4. For each 100 feet of total lift, the submergence should be from 50 to 60 per cent. to get the best results.

Reciprocating pumping engines are the ones in general use, the plungers being either horizontal or vertical as will best suit the local conditions. Nearly all pumps are double-acting, that is, consist of two sets of inlet and delivery valves with a reciprocating plunger or piston working in a barrel communicating with the two valve chambers. Such pumps are, therefore, both suction and delivery pumps. The flow of water through such a pump is intermittent, and to relieve the pipes and the pump itself from violent shocks an air chamber is provided. The largest air chambers are required for single pumps; much smaller ones will suffice for duplex pumps, and, in some cases, they are omitted altogether.

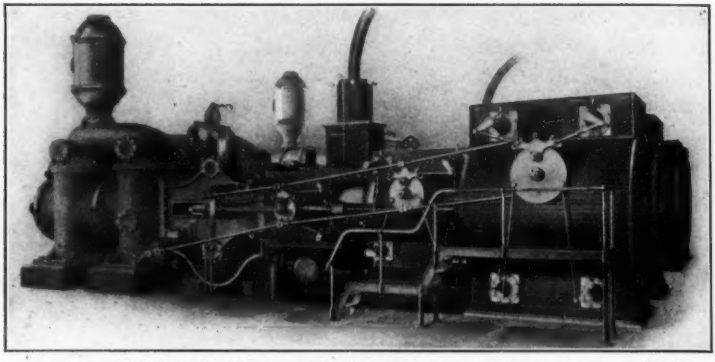
Ordinary direct-acting steam pumps are very wasteful of steam, more so perhaps than any other type of steam-driven machinery. Tests made to determine the efficiency of the auxiliary machinery on board the United States warships showed that as much as 200 pounds of steam were used per indicated horse power per hour. For small water-works plants and other service where a constant supply of water is required, an economy is had by compounding the steam cylinders, though in most cases even this does not give the economy supposed. Large compound condensing pumping engines of the duplex type yield a duty of from 50,000,000 to 70,000,000 foot pounds per 100 pounds of coal burnt. This is the best average duty which can be expected of similar pumping engines in mines, acting under the best conditions.

A compensating device applied to the water end of a direct-acting pumping engine by which a degree of steam expansion similar to that of rotative steam engines becomes prac-



STEAM AND WATER ENDS, 5,000,000 GALLON PUMPING ENGINES.

Cylinders 13, 19, and 30 in., water plungers 20, stroke 36. Epping-Carpenter Co., Pittsburg.

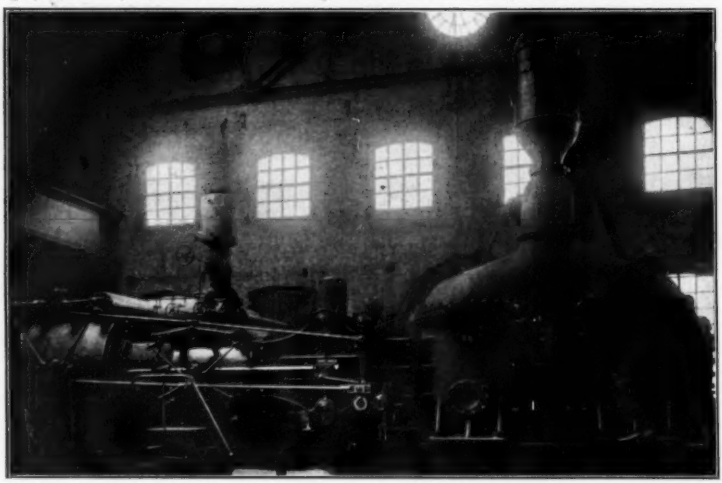


HIGH-DUTY TRIPLE-EXPANSION PUMPING ENGINES, MOUNT ROYAL STATION, BALTIMORE.

Daily capacity 17,500,000 gals. each; duty on official trial, 142,334,000 foot pounds per 1,000 pounds dry steam. Henry R. Worthington, N. Y.

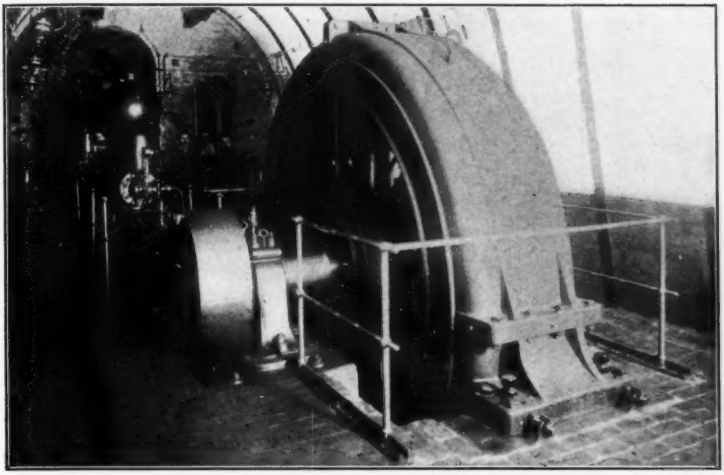
ticable, will yield a correspondingly high duty. More than 100,000,000 gallons can be secured under good average conditions, using steam of 160 pounds per square inch.

Crank and fly-wheel pumping engines have yielded the best average high-duty performance. The pumping engine at the Chestnut Hill Low Service Station, Boston, Mass., has steam cylinders of 17, 31¼, and 48 inches diameter by 60 inches stroke; the water end con-



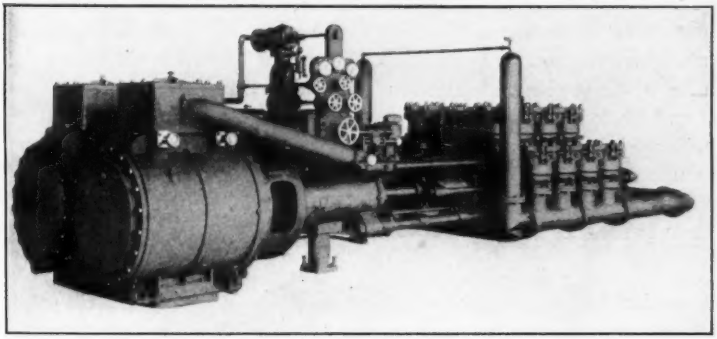
"WORTHINGTON" HIGH-DUTY DIRECT-ACTING PUMPING ENGINE, LANCASTER, PA.

One of the latest large installations built. R. D. Wood & Co., Phila.



UNDERGROUND ELECTRICALLY DRIVEN PUMP, SOCIÉTÉ ANONYME DES HOUILLÈRES UNIES DU BASSIN DE CHARLEROI.
Schleifmühle express pump, by Ehrhardt & Sehmer, driven by International Electric Company's three-phase motor.

sists of three single-acting plungers 37 inches in diameter. The valve area is 200 per cent. larger than the plunger area. At 30 revolutions per minute the plunger speed was 300 feet per minute. The average net head pumped against was 45 feet. The efficiency of the mechanism was 88.84 per cent., with thermal efficiency of the engine of 20.50 per cent. With steam pressure at 150 pounds per square inch, the duty of the engine, based upon plunger displacement, was 158,574,000 foot pounds. As this represents an indicated horse



WOOD LINED PUMP FOR 800-FT. LIFT, P. & R. COAL & IRON CO.
Jeanesville Pump Co., Hazleton, Pa.

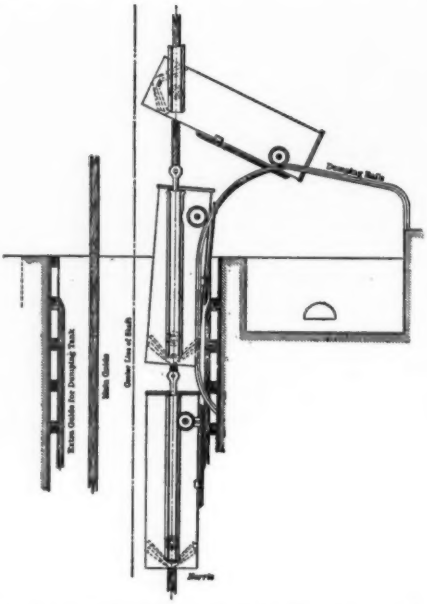
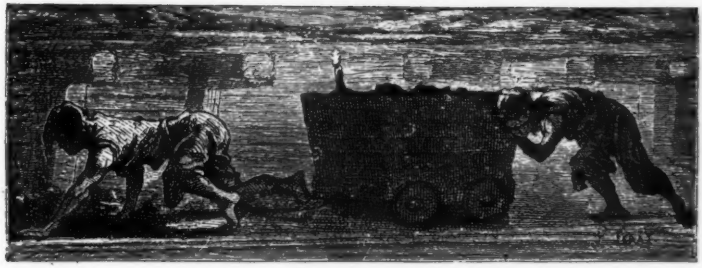


DIAGRAM SHOWING GUIDES AND METHOD OF DUMPING, WATER HOISTING BY MEANS OF DUMPING TANKS.

R. V. Norris, T.A.I.M.E., Feb., 1903.

power for each 11.08 pounds of dry steam, but little is to be expected in the matter of greater efficiency.

Water hoisting from deep mines, by means of tanks instead of by pumping, is now coming into favor in the anthracite region of Pennsylvania. Many of the large collieries are now hoisting water in this manner, and others are thus equipping their mines in lieu of pumps. At the William Penn Colliery of the Susquehanna Coal Company, the tanks are about four feet in diameter by some sixteen feet in height, the estimated capacity being 193 cubic feet with a rated capacity of 281,400 cubic feet in 24 hours, the mine being 953 feet deep; this is equivalent to more than 2,000,000 gallons per day. These tanks are constructed with two butterfly valves at the bottom, set at an angle of 45 degrees. A sump is provided in the mine into which the tank descends; after filling it is hoisted to the top of the mine where it pours its contents into a discharge basin, from whence it can be led to any convenient waste. The duty of such a water hoist varies between 30,000,000 and 40,000,000 foot pounds per 1,000 pounds of dry steam. In this case a pair of engines 32 by 48 inches with drum 12 feet in diameter handled water at a cost of $0.0234 per 1,000 gallons, or $0.1755 per 1,000 cubic feet.



"PUTTERS" OR TROLLEY BOYS IN AN ENGLISH COAL MINE, EARLY NINETEENTH CENTURY.

Women and girls were employed at the same work up to 1843.

A DISCUSSION OF METHODS OF UNDERGROUND TRANSPORTATION.

By John Bonsall Porter.

Mine transportation, to be properly discussed, must be considered under two heads—haulage and hoisting. It is unfortunate that time and space permit the treatment of one only in a single article, for the two are so inter-connected that neither can be shown alone in its true perspective. In many mines haulage and hoisting are one—the haulage road reaching from the surface to the extreme bottom, but being so steep that its function is really closest to that of hoisting. In others, the haulage roads are graded to the shaft to lighten the work of horse or hand tramming, the saving thus effected more than off-setting the added hoist. In still others, including many collieries, the shaft cuts the bed at an intermediate depth and the haulage system is required to raise the material from the deeper workings to the shaft level. Only in the comparatively few mines in which the workings are reached by tunnels to the rise in hillsides are haulage and hoisting separated (by the elimination of the latter). In all other cases they are so closely related that each is dependent upon the other for its success. Dr. Porter's paper is therefore but initiatory to the complete discussion, and is to receive its complement in a review of hoisting to be presented later.—THE EDITORS.

THE statistical sheets recently published by the United States Geological Survey show that in 1903 the mines of the United States produced about 350,000,000 tons of coal and 70,000,000 tons of ore and other mined minerals. American statisticians do not distinguish between mining proper and quarrying or open-cut mining, but it is safe to assume that 325,000,000 tons of coal were produced in underground workings at an average distance of at least 3,000 feet from the pit's mouth. A larger proportion of the ore was produced by open workings, but underground mining probably yielded 45,000,000 tons for which an average haul of 300 feet may be assumed. We thus have an aggregate haulage underground of about 180,000,000 ton miles in the United States alone.

LOWERING A HORSE INTO A MINE.

If we extend our enquiry and include the mineral production of the whole world, we find that underground mining produced last year not less than 1,000,000,000 tons of mineral, of which over 80 per cent. was coal; and the transportation of this material involved nearly 500,000,000 ton miles of haulage, and probably 70,000,000 ton miles of hoisting. These figures are rough approximations only, but they suffice for our purpose, and show that underground transportation is a subject worthy of the most careful attention of engineers and managers. A not inconsiderable part of the mineral above referred to was produced by a great number of small mines in which simple—and in some cases almost primitive—methods are of necessity employed, but by far the greater part came from comparatively large plants, in which economies of transportation are or should be considered as carefully as if on the surface. It will therefore be interesting to see how far the mineral industry of the present day has benefited by the devices and methods of modern engineering.

With a few notable exceptions, the mines of a century ago were small. Shafts were occasionally quite deep, but, owing to the great first cost and limited capacity of the pumping and hoisting apparatus then available, only a small territory could ordinarily be worked from each shaft. The material mined was usually hauled in sleds or little waggons, or even carried on the backs and heads of the work people from the face to the hoisting apparatus. In some places horses were in use and rough tramways were laid with planks or even with cast-iron plates, but in general the workings were too small and tortuous for anything but human transportation, or perhaps we might now call it *inhuman*, as women and boys did most of the work.

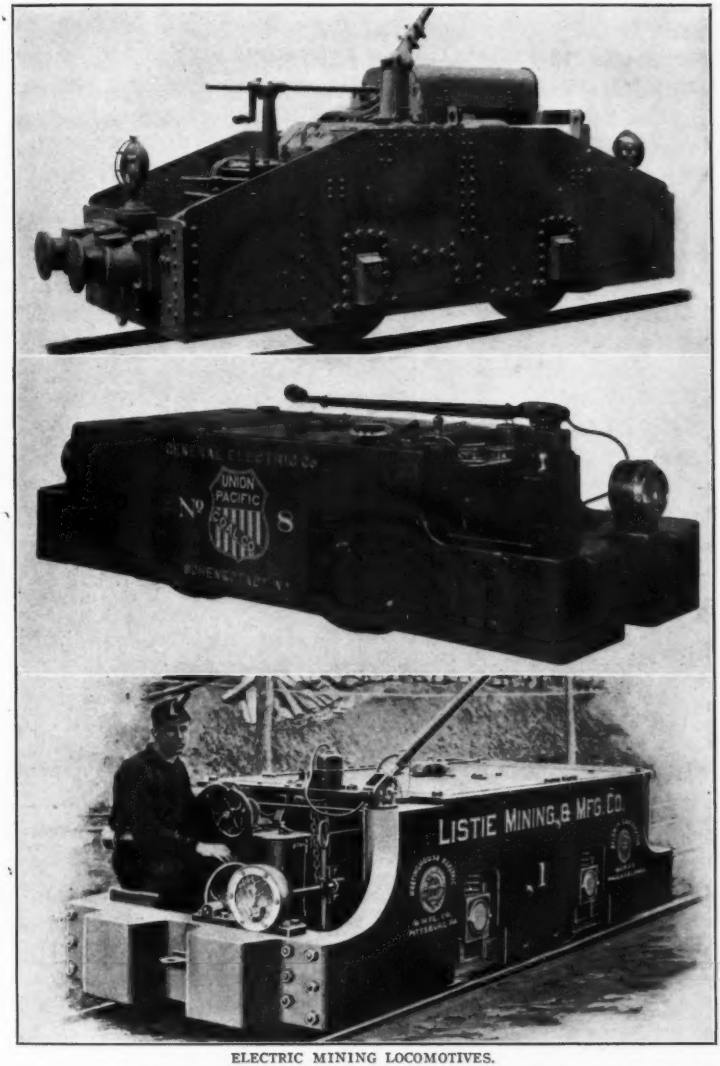
The first half of the nineteenth century brought many improvements. Hoisting and pumping machinery were greatly simplified and cheapened, thus making it economical to work much larger areas from each shaft. The labour of women underground was prohibited, and motives of economy as well as humanity caused a general introduction of horse haulage in collieries, although the wheelbarrow and even cruder devices remained in almost universal use in ore mines as in fact they remain in many places even to the present day. Until about 1840 such mine cars as were in use were really buckets or corves, provided often with small wheels to facilitate their handling, but moved from loading place to shaft bottom on wheeled platforms or rolleys, thence hoisted to the surface, emptied, and returned to the pit. About the year mentioned corves and rolleys began to give way to cars very similar to those now almost universally used, the roadways being at the same time improved and laid with better rails. Slopes operated by ropes were already in use, and within the next twenty years these became comparatively common and were developed into more or less elaborate systems of main, tail, and slope-rope haulage. The condition of affairs in the best mines of the day is clearly set forth in a report by a committee appointed by the North of England Institute of Mining Engineers in 1867 in which the several systems of rope and endless-chain haulage then in use are described and discussed. Tail ropes and endless chains are recommended for

HORSE HAULAGE IN A COAL MINE, SOUTH STAFFORDSHIRE, ENGLAND.

ordinary use, while endless rope is recommended only for certain special cases. Of the eleven selected English plants discussed by the committee three were slope and tail-rope systems with an average working tonnage of 503 per shaft. Five, with an average tonnage of 342, were endless chains, and three, with an average tonnage of 350, were endless rope. Horse haulage was of course used in all of these mines to bring the cars to the main tramway, and boys were employed to carry the coal from the working places to the cars, in many instances, and to actually haul the cars in some cases. The success of these mechanical-haulage devices and of important improvements in ventilation, which were introduced at about the same time, greatly increased the territory accessible from a single opening, and coal mines in all civilized countries were soon equipped with mechanical devices more or less equivalent to the street-railway cables so commonly used in our cities a few years ago.

In 1870, a steam locomotive was used underground in one of the collieries in the United States. In 1882, an electric-haulage plant was installed in the Zaukeroda colliery, in Saxony, compressed-air locomotives having been employed in England and elsewhere shortly before. The first electric locomotive used in the United States was at Lykens Valley, in 1887. As might have been expected, the steam locomotive has not proved very successful underground; but pneumatic and electric machines have become increasingly common, and while it is impossible to state their present number or their proportion of the world's tonnage, it is safe to say that there are in the United States alone not less than 2,000 electric, and probably about 150 pneumatic locomotives in underground service.

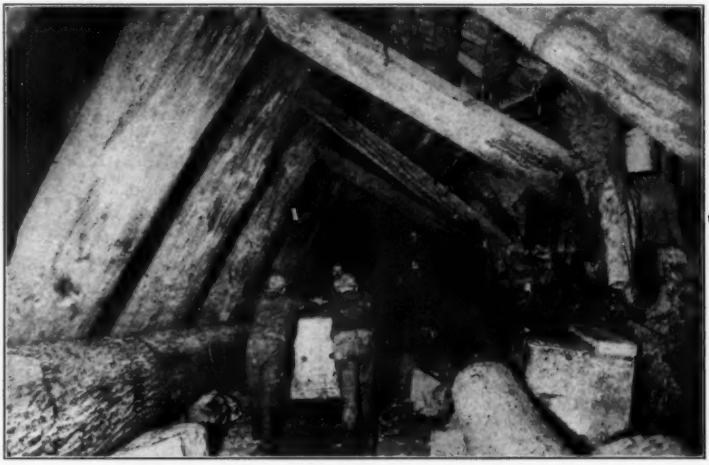
In surface transportation, when a system is improved upon, its older forms rapidly become obsolete and are abandoned. Horse cars and cable cars are no longer seen in any important service, although an enormous number of them were in use only a few years ago, and even the peumatic and the earlier electric cars have almost disappeared. In mining, the conditions are very different. When a plant is once installed, it is usually left in service until it is worn out, or until there is some very pressing reason for changing it. It is out of sight of the public and is rarely subject to competition, much less to comparison with other and more modern installations. While this condition often retards development, it is not an unmixed evil, as a mine usually has but a limited period of profitable operation, at the end of which it is abandoned. It cannot therefore bear excessive expenditures on capital account, even when they cheapen operating costs. The result is that we have in the mines of the present day,



ELECTRIC MINING LOCOMOTIVES.

The topmost is by Mather & Platt, Manchester, 2 ft. 5½ in. track gauge, 5 ft. 6 in. by 5 ft. 3 in. load gauge, weighing about 4 tons; tractive power 1,100 lb.; speed 10 miles; 500-volt current. It was supplied to a mine in Spain. The middle one is by the General Electric Co., Schenectady, N. Y. The lowest is by the Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

and often in plants working under almost identical conditions and in close proximity to one another, examples of almost every type of mine haulage that has been developed during the last century, and it is therefore possible to compare these different methods on a fairly even basis, and to discuss the conditions under which the use of each is justifiable. Taking the systems then in historical order, let us first describe and then briefly comment upon them:



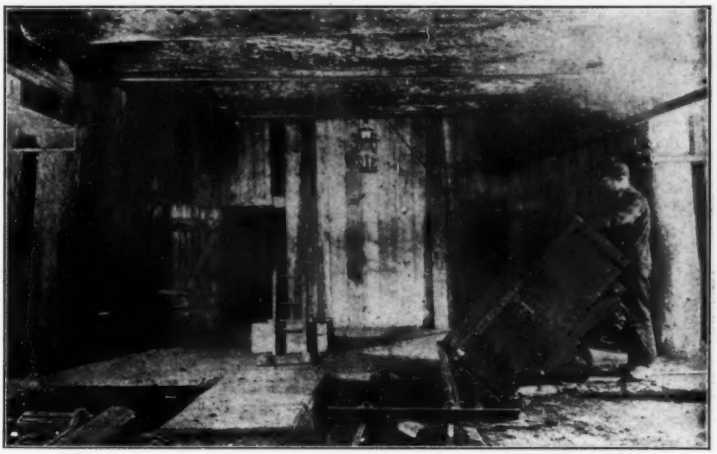
TRAMMING IN THE TAMARACK MINE, MICHIGAN.

Human haulage with sleds and baskets holding about 100 pounds is said to exist even at this late date in some of the very thin iron-stone and coal mines of Great Britain, and it is, of course, common in out of the way countries, where labour is very cheap. Tramming under somewhat better conditions is still very largely employed in all countries. Even in collieries where the seams are thick, cars are moved at the face and trammed short distances. In thin seams, especially where the long-wall system is used, this hand tramming is carried on to a much greater extent, as roads high enough for horse or power haulage have to be cut partly in rock, and are therefore too costly to be very close together. In metal mines, which usually have several levels working at once, each with comparatively short hauls, human labour is still more commonly used, and probably 90 per cent., if not 95 per cent., of all ore both in America and elsewhere, is still hand trammed from the working places clear to the shaft.

The use of horses and mules is still increasing in spite of the fact that power haulage is far more economical. This is chiefly due to the

fact that until very recently power haulage has been confined to the main roadways; and although animals have ceased to give economical service there, it has been found necessary to employ increasing numbers of them for secondary service, and the great extension of the mineral industry has caused this secondary work to grow to greater proportions than that of the total haulage of a few years ago. It is almost impossible to get any accurate figures as to the actual number of animals employed at present, but in the State of Pennsylvania alone 29,771 horses and mules were employed underground in 1903. A large number of these animals are stabled in the mines, and, after once going below never again see daylight, although their average life in mining service is probably not less than seven years.

Rope haulage as now employed in mining is of two different types. First, that employing gravity for taking the cars one way, and therefore akin to slope hoisting. Second, endless-rope haulage, which has much in common with the cable transportation recently



DUMPING A CAR INTO AN ORE BIN IN A MINNESOTA IRON MINE.

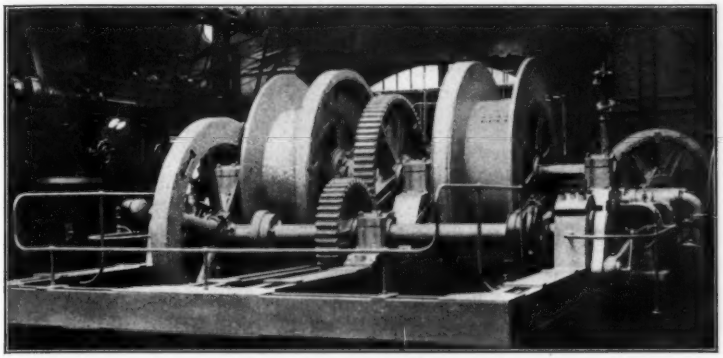
used for street-railway service. The first system, as employed in long and steep slopes reaching to the surface, can properly be referred to hoisting, and need not be further discussed; but in all collieries where the seams are at all steep, there are places where underground slopes can be used to advantage, and the cars in this way lowered from the rise workings to the main road, or raised from the deeps to the shaft, or to some line leading to it. The simplest form of this arrangement is seen in the jig or balance employed when working to the rise in moderately steep seams. The main roads are

driven almost level, and from these, rooms are broken off and cut into the coal either directly up the pitch, or, if that is too steep, at an inclination to it. Temporary tracks are laid up these rooms as the work progresses, and at the top of each a small sheave is attached to a stout post and around this a rope is passed and connected with two cars, one at the top of the track and as close to the work as possible, the other at the bottom, and empty. As soon as the upper car is loaded it is started down the track, which is arranged with a double line at the passing point, and the empty car is thus automatically raised to the working place, the load being taken off to the main line by the secondary haulage and replaced by another empty, while the new car is being filled. Similar devices, but of more substantial construction, are used to connect any groups of rooms, which happen to be at a high level, with main lines below them, and the tonnage thus handled by gravity is very large in the aggregate. In the case of workings on the dip side of the haulage lines, these inclines have to be run by power, but when served by small electric or pneumatic motors, they are very economical and satisfactory.

The slope-rope system is a modification or development of this system of power-rope haulage. An engine provided with a winding drum of the necessary capacity is placed at the head of an inclined

SELF-ACTING INCLINE HAULAGE OR JIG.

The gear is placed at the top of a room when working to the rise, and when a car has been loaded it is lowered. Its weight draws up an empty car to take its place.



A HAULAGE ENGINE FOR HEAVY WORK.

Hauls 50 tubs, each weighing 13¼ cwt., up an incline 1,800 yds. long; 500 yds. is on a grade of 1 in 6, the rest 1 in 20; maximum speed 1,300 ft. a minute. Twin cylinders 17½ by 36, drums 6 ft. diam.; 370 indicated horse power.

Fraser & Chalmers, Ltd.

road leading to the deeper workings, and trips of cars, often aggregating a considerable train, are lowered by gravity to any point where they are needed. The rope is then attached to trains of loaded cars which have been made up, and these are hauled out and delivered either to the hoist direct, or to some other system of transportation connecting with it or the surface. This system requires single track only, and a single plant can be used to work a number of slopes if they can all be reached by gravity from the same starting point. Its disadvantage is that the service is of necessity intermittent, and that the hoisting suffers from successive periods of congestion and a dearth of cars; furthermore, its capacity is very limited unless high speeds are employed, and haulage at high speed necessitates costly track, and often involves derailment and serious loss of time and money. The system is admirably suitable for comparatively small mines on inclined seams, and for isolated portions of larger establishments; and by a modification technically known as the "main and tail-rope" system, wherein a light rope from a second drum is carried to the end of the road and brought back to connect with the lower end of the trip, it can be applied to roadways in which the grade is insufficient or even slightly adverse.

Rope haulage can be made far more effective, and its output can be greatly increased, by using double lines of rails and an endless rope moving at comparatively low speed. Such a line travelling at say two miles per hour can work on any grade up to 30 or 40 per cent., and can carry single cars spaced as close as 50 feet, or small groups of cars at correspondingly greater distances, and under these

conditions will handle one hundred cars per mile, or say 400 tons per hour. In practice the rope can seldom be so uniformly loaded as to give this result, and there are always occasional stoppages of the whole line caused by interference at junctions. In spite of these causes, many plants average 200 or 250 tons per hour in regular service, and 3,000 tons per shift of ten hours has been exceeded.

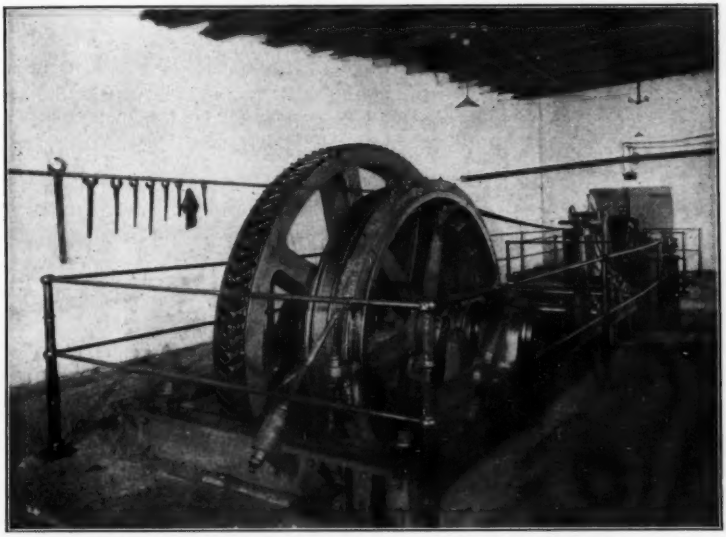
The cars are attached to the rope by ties or clips, the latter often being so arranged as to release automatically at the terminals. The speed is so low that empty cars can easily be released and switched by hand at junction points, and loads similarly run in and attached.

The great advantage of this rope system is the certainty and regularity with which it delivers loads to the hoisting plant and removes the empties, thus rendering it possible to hoist under the most favourable conditions. The low speed also insures a minimum of derailments and other accidents, and when these do occur they are far less likely to be serious than with any of the other systems.

A JUNCTION ON A HAULAGE PLANE, SOUTH STAFFORDSHIRE, ENGLAND.

The first cost of an endless-rope system is probably greater than that of any other haulage, for not only is the plant itself costly, but the roadway has to be made wide enough for double track, or driven double when the roof will not permit of this. The operating costs are also comparatively high owing to the wear of the rope and rollers, and to the heavy losses from friction, which become excessive on long and especially on crooked lines with many curves. The system is, however, so eminently satisfactory in many other respects, that it

still finds many advocates even for cases where electric or other independent motors are practicable, and for roadways which have heavy grades it is still the only proved system.



ELECTRIC-DRIVEN ENDLESS-ROPE HAULAGE GEAR, CAROLINE PIT.
Driven by an electric motor of 90 brake horse power, with Hall friction clutch gear. By Ernest Scott & Mountain, Ltd., Newcastle-on-Tyne.

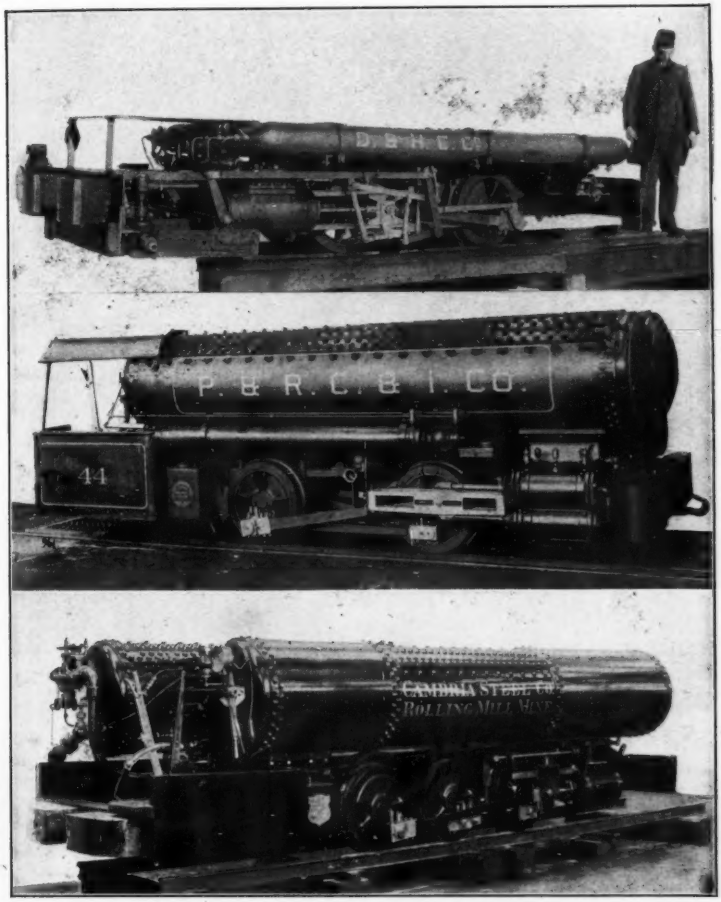
Haulage ropes are sometimes led to the surface, and there driven by steam engines or other motors, but ordinarily the drums or driving sheaves are placed underground near the home terminus of the line. They were formerly almost exclusively driven by geared steam engines, and this method is still frequently employed, but the transmission of steam down the shaft is always wasteful and in some cases dangerous. In a number of plants, rope transmission from the surface has been found satisfactory, but in recent installations, especially in England, electric motors have been largely used.

Slope haulage and auxiliary rope lines at a distance from the shaft were usually driven by compressed-air motors or by some connection with the main haulage ropes. In many cases the bore holes are now used, giving direct rope connection with the surface, but the most common practice at present is to employ electric power. For this service both direct-current and induction motors have been found quite satisfactory. The former are probably more economical when not too far from the source of electrical power, but the latter permit of cheaper and more efficient transmission to long distances and are

practically sparkless, a condition of the utmost importance in mines troubled with explosive gas.

In the United States, where most of the coal comes from large seams, and where faults and irregularities are fewer than in less favoured places, the use of independent motors has become very common during the last few years. With certain special exceptions, these motors cannot work to advantage against grades of over 4 per cent., or with grades more than double this, but under favourable conditions they afford the cheapest haulage of the present day. Steam locomotives were the first to be used, and colliery statistics show them still to be very numerous in mining work, but most of them are employed either on the surface or on lines chiefly above ground, and comparatively few are now continuously employed in underground service because of their interference with ventilation and of the increased risk of fire. At best they are only adapted to use in main roads which are large and close to the surface, and even there it is necessary to exercise great care to prevent accidents due to asphyxiation and carbonic-oxide poisoning. Electric and pneumatic locomotives, on the other hand, are admirably adapted to underground service, and within the last decade both types have been so developed that we now have a number of excellent machines in each of several classes,

HAULAGE SLOPE AND TIMBER YARD, WESTVILLE-PICTOU CO., NOVA SCOTIA.

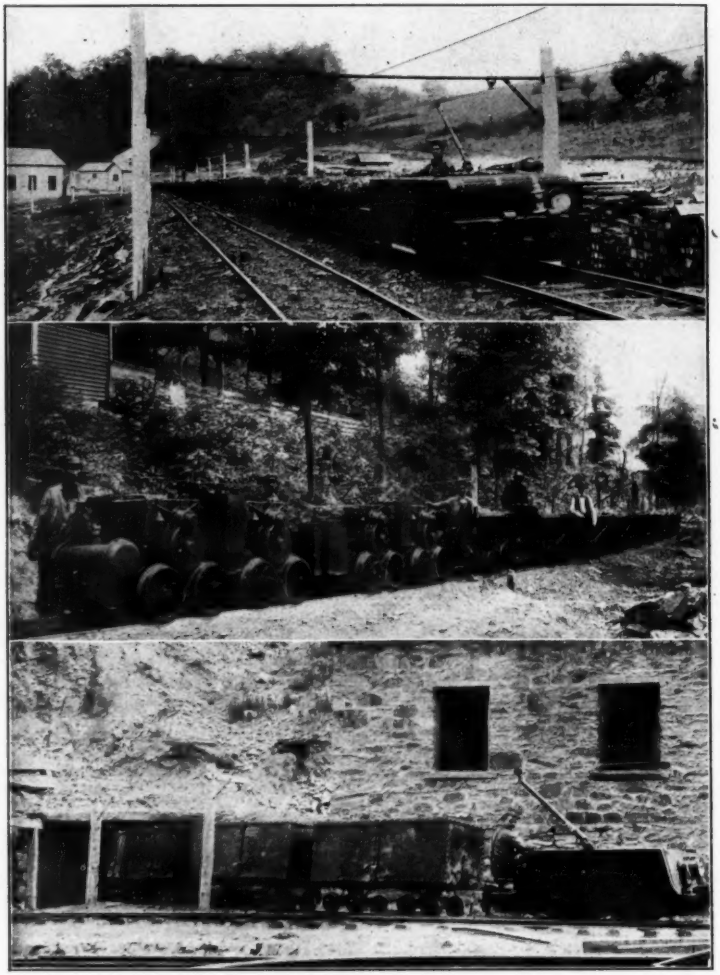


TYPICAL COMPRESSED-AIR LOCOMOTIVES FOR MINING USE.

The topmost is made by the Dickson Locomotive Works, Scranton, Pa.; it is for 3-ft. gauge, and is 35 in. high above the rail and weighs 13,100 lb.; 700-lb. storage pressure, 125-lb. working pressure, 3,080-lb. tractive power; 7-in. cylinder, 14-in. stroke. The middle picture shows an air locomotive from the Baldwin Locomotive Works, 3-ft. 8-in. gauge, weight 21,880 lb.; cylinders 5 and 8 in. by 12 in. The locomotive at the bottom is made by the H. K. Porter Co. for the Cambria Steel Co.'s mines. It is 3-ft. gauge, 5-ft. 3¼-in. high, and weighs 27,000 lb.; tanks 16 and 18 ft. long, 33 in. outside diameter; pressure 700 lb.

and where the grades are not too great, train haulage with these motors compares very favourably with the best work done by ropes.

In most mines large enough to have power haulage, the shaft or entry and certain main roadways are comparatively permanent,



ELECTRIC MINE LOCOMOTIVES IN SERVICE.

The uppermost picture shows a locomotive built by the Baldwin Locomotive Works, and in service at the Eureka Mines of the Berwind-White Coal Mining Co. Two 50-horse-power 500-volt motors. Weight 26,000-lb., starting draw-bar pull 5,200 lb. The middle one represents a third-rail electric locomotive by the Morgan Electric Machine Co. at the mines of the Collins Colliery Co., Glen Jean, W. Va. The lowermost picture is taken in the Lake Superior iron region and shows an ore train pulled by an electic locomotive made by the Jeffrey Mfg. Co.

and can properly be made of such size, and with such grades and curves, as will ensure rapid and economical transportation; but even

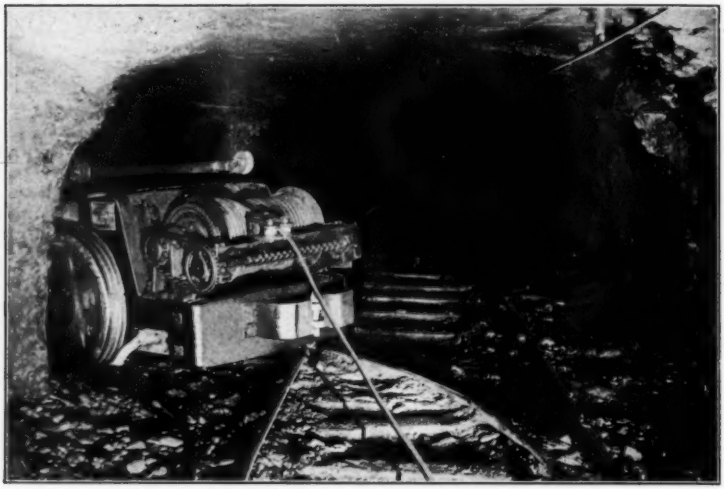
STEAM MINE LOCOMOTIVE, ELKHORN COAL & COKE CO., MAYBURY, W. VA.
44-inch gauge, cylinders 10 by 14 in., boiler pressure 150 lb., tractive force 6,375 lb.; weight about 30,000 lb., height above rail 5 ft. 6 in. Built by the H. K. Porter Co., Pittsburg, Pa.

in these main arteries of the mine, the dimensions of the headings must be kept down as far as is reasonably possible in order to lessen first cost and maintenance expenditure. These roads cannot in the nature of things extend quite to the working places at best, and ordinarily the actual mining operations are carried on at considerable distances from them, and cars, whether loaded at the face or at batteries or chutes, have to travel over long stretches of rough track in the workings and through narrow, tortuous, and more or less temporary lines of communication to the nearest points on the main road.

These conditions obtain whether we use rope or motor haulage, and until recently the universal practice has been to employ horses or men for this secondary service of handling the cars between the loading places and the nearest main-road points. With the independent motor, however, the advantage of being able to run out into the workings is so obvious that efforts have been made to produce machines which could work on poorer tracks and sharper curves than are permissible on the main line, and thus to reduce the secondary haulage as far as possible. Pneumatic locomotives have been particularly successful for this service, as they are independent of trolley connections, and need only a practicable line of rails. They also have the advantage of being absolutely sparkless and thus safe in the most gaseous places, and of having approximately maximum efficiency through a wide range of speeds.

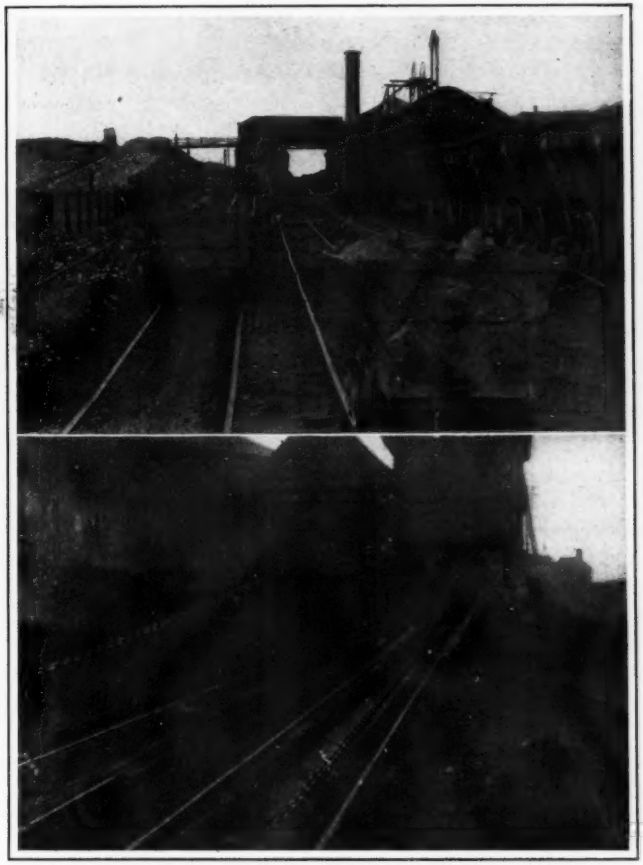
They even aid somewhat in the ventilation. Their disadvantage is that they can carry but a limited supply of compressed air, and therefore have to return to the supply pipes at comparatively short intervals. They are also very bulky as compared with steam or electric motors of equal tractive force, on account of the comparatively large size of even such tanks as are necessary to carry air for a single

trip of any extent. Compressed-air machines are also of comparatively low efficiency, and although this objection can be greatly lessened by reheating with superheated water, this again increases the bulk of the machine.



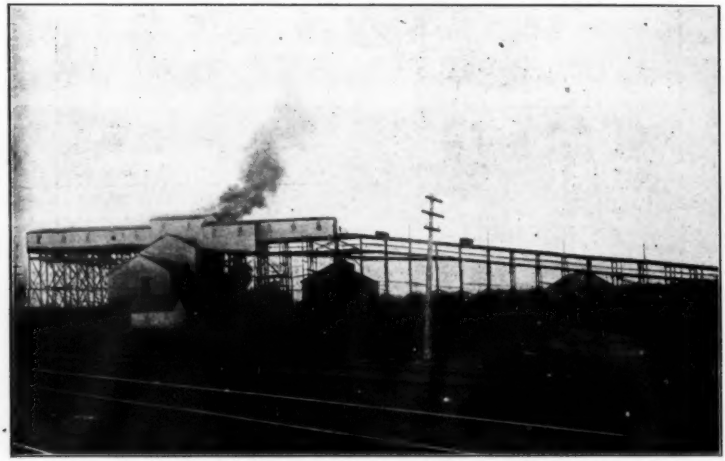
2½-TON ELECTRIC GATHERING LOCOMOTIVE WITH CABLE REEL, EMERGING FROM A ROOM INTO A MAIN HAULAGE ROAD WITH A LOADED CAR.
Jeffrey Manufacturing Co., Columbus, Ohio.

Electric locomotives are very compact and flexible as compared with the other two types of independent motors, but of course have to remain in constant connection with the service wires. Fortunately trolley wires cost little to erect and a comparatively short term of service will justify their use in a secondary line. The difficulty of reaching the rooms still remains, but this is now being met by the use of flexible cables wound upon reels carried by the motors themselves. These cables are not used in the ordinary main-road service, but, when a motor wishes to leave a line and run into the rooms, the cable is connected with the main wire, and is paid out as the motor travels further into the mine. By an ingenious device sufficient tension is always kept on the reel to prevent excessive unwinding and kinking, and when the direction of the motor is reversed the reel automatically draws in its cable. These gathering locomotives are as yet too new to be spoken of with absolute certainty, but there is every reason to feel hopeful that they, or some equivalent device, will make electric traction perfectly practicable to the very face of the workings in all mines which are not too gaseous.



THE UPPER PICTURE SHOWS ENDLESS-ROPE HAULAGE AT SEATON DELAVAL COLLIERY; THE LOWER, ENDLESS-CHAIN HAULAGE AT A COLLIERY IN THE MIDLANDS OF ENGLAND.

As far as colliery haulage goes, we may perhaps take the present state of affairs in the United States as an indication of the probable future practice in mines in which the size and slope of the coal renders independent motors practicable. The deepest and most gaseous mines in the country are those of the Pennsylvania anthracite regions. In these there were, in 1903, 71 pneumatic and 84 electric locomotives in use, the latter presumably in the less dangerous mines. In the Pennsylvania bituminous regions there were 23 pneumatic and 435 electric locomotives, and in the rest of the United



SLOPE AND TIPPLE FOR ENDLESS-ROPE HAULAGE, DOMINION COAL CO., GLACE BAY, N. S.

States and all Canada, as far as figures are available, there were about 60 pneumatic against 1,500 electric machines.

Another danger from the electric locomotive is the bare trolley wire or third rail, which cannot always be kept out of reach and which no regulations will keep men from touching. I can state from personal experience on several occasions that 220 volts direct current may be taken on the head and even through a pair of gold spectacles without fatal results to a man of ordinary strength. Nevertheless a number of miners, presumably men with weak hearts, are killed each year by such low voltage, and higher pressures or alternating currents are of course more dangerous. Accident reports show, however, that almost as many men are killed, and vastly more are injured annually by being kicked or bitten by horses and mules, and these amiable animals have the added disadvantage underground of fouling the air to five or six times the extent of an equal number of men. Stables are also responsible for a considerable percentage of all serious mine fires.

Thus far little has been said about the cost of mine haulage, and it is impossible to give any figures comparable either for accuracy or general applicability with similar figures for surface transportation. Mine tracks at their best are rough. Another disadvantage is that the traffic is concentrated at one end of the line only, and that it is distributed at the other among a large number of sub-stations, thus involving irregular and uneconomical train service. In spite of these difficulties, the actual ton-mile costs have been reduced to very reasonable figures, some of which it may be interesting to give.

Human haulage or tramming as practised so largely in metal mines, and somewhat in collieries, is very costly—averaging certainly above 20 cents per ton mile and often far exceeding this. Even power haulage is costly for the short distances common in metal mines, but wherever the traffic is at all heavy, it is far cheaper than tramming, and the recent rapid extension of electric and even rope haulage in Michigan and the West shows that managers are beginning to appreciate this fact. Horse haulage ranges between 2 cents and 20 cents per ton mile, but probably averages about 8 cents. Rope haulage on level roads costs about half as much—probably 4 cents is a liberal estimate—but when employed on steep grades it is more costly as it combines hoisting with haulage proper. Electric and pneumatic haulage are both cheaper than the older systems, and both have shown extremely low costs, reaching say 1½ cents per ton mile in certain special cases; but these extreme figures cannot be properly compared with those given above for horse and rope haulage. It is safe, however, to say that, in services to which they are adapted, pneumatic locomotives are at least as cheap as endless rope and have the advantage of independence, while electric motors are probably one-third cheaper in the average than rope and appreciably cheaper than pneumatic.

This paper has been devoted chiefly to a discussion of American practice, partly because the author is more conversant with American mines than with any other, but chiefly because the great mines of America are of such a nature, and have been developed under such conditions, as to give every facility for the rapid and successful introduction of the most modern devices and methods.

A new mine on a thick and reasonably level seam can often be equipped throughout with the most modern electric or pneumatic machinery, including a system of haulage reaching from the entrance to the very working places, and such a mine will of course show extremely low operating and transportation costs. On the other hand, deep mines in troubled ground can seldom be arranged for any one system, and in many cases several different systems of haulage have to be fitted together into one harmonious, if complex, whole.

If instead of a new mine we take the case, almost universal in England and common enough in America, of an old and extensive mine already provided with reasonably effective transportation, the matter is still more difficult, and the manager of such a mine is usually fully justified in holding to the old methods in general, although he should of course make every effort to increase their efficiency by the use of modern appliances whenever practicable.

POWER GENERATION AND TRANSMISSION FOR A MODERN MINE.

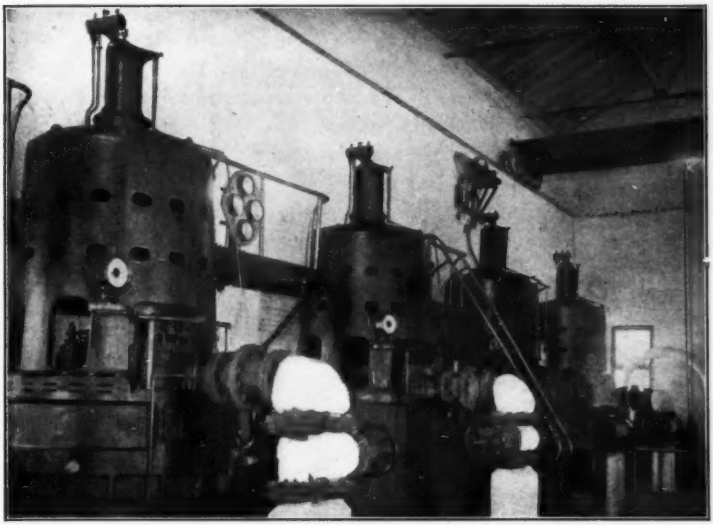
By E. H. Roberton.

While the power applications in the mine are highly specialised, the generating plant proper is of course essentially like that employed for other large undertakings. Mr. Roberton therefore confines himself to such points of distinction and difference as are to be noted, and does not attempt the enormous, and in this place needless, task of reviewing power plant in general.—THE EDITORS.

THE question of power generation and transmission opens up a more extensive field of possibilities and uncertainties to the miner than perhaps to any other class of engineer. The costly plant that may have already been in operation some time, the possibility of introducing a factor of danger into works so far comparatively free from it, and the uncertainty in the case of electricity at least of future legislation that may nullify or hamper the good effects of a new and expensive equipment—all these are bound to exercise a deterrent effect on the engineer who meditates a new departure in the generation of power.

Speaking with reference primarily to existing British practice, in coal mines, as is natural, steam is almost universally used for power generation, while in slate and metalliferous mines, situated as they often are in hilly and well-watered districts, water power is the rule. In the latter the old-fashioned water-wheel, coupled direct onto shafting, which proves to be so great a nuisance in frosty weather, is rapidly being replaced by the hydraulic turbine, or the Pelton wheel, in conjunction with a dynamo generating electrical power for distribution to the various machines. In the former the change is much less rapid, and there is much debate as to what method of transmission of power will prove of the greatest utility.

An alternative for the generation of power in coal mines, specially suited for such districts as the Black Country where there are many spoil heaps consisting almost entirely of rejected small coal, or for such mines as draw out of their shafts quantities of unsaleable slack, is the manufacture of producer gas from the slack, and the generation of electricity by means of gas engines. Or the same slack might be turned to use in boilers in conjunction with forced draught, and electrical power distributed for use throughout the district. The latter system is in practical use at Wallsend, supplying electrical power to the district around Newcastle-on-Tyne, and has proved very success-



A MODERN CENTRALISED MINE POWER PLANT. HAMPTON CENTRAL STATION, D. L. & W. R. R.

Five 500-k.w. Curtis vertical turbines, driving three-phase 60-cycle 2,300-volt General Electric alternators. The current is stepped down at mine sub-stations to 275-volt direct current, by rotary converters, and the power used for haulage, slope work, pumps, etc., over a radius of about three miles. The illustration was secured by the special courtesy of Capt. R. A. Phillips.

ful, so much so that additional similar central generating stations have been proposed to supply power to other colliery districts in the same part of the country. Such is, however, the thermal efficiency of gas engines using producer gas, that it is probable far better economic results would be obtained in central stations employing the latter.

The general impression produced by an inspection of the mines in Great Britain is that for the most part they are in a transition state in regard to power distribution, so many and varied are the methods employed, even over a narrow area. In one group of collieries known to me, both electricity and gas were used for lighting purposes; ventilation was effected by steam power and by furnaces; haulage was by steam and animal power; underground pumps were worked by transmitted steam, rope transmission, and an oil engine, and an experimental plant for coal-cutting by electricity was fitted up. In a neighbouring colliery compressed air was used for coal-cutting and underground haulage, while again in another electricity was used for the same purposes. Such a heterogeneous collection of power, spread over a comparatively small area, although it is the natural growth of

years, cannot lead to the very best economical results; but whether all these collieries will ultimately combine to use the same power for all purposes, drawn from a central station, time alone will shew.

In all mines the broad lines of choice for transmission of power, either over the surface works or underground, lie between steam, hydraulic, rope, compressed air, and electrical transmission; and a thorough invstigation of the conditions to be met with, and of the effects required, must be instituted in each particular case, before choice can be made of the most suitable mode of power distribution. The conditions which differentiate mines from other classes of works in which transmitted power is required, may be briefly summed up as:—the necessity of carrying power down a shaft which is probably very damp, and through which there is a strong current of air constantly travelling; the long and tortuous ways through which it must be guided; the constant passage of men and animals, rendering necessary extra precautions against accident to life and limb; the possibility of injury to pipes or cables from falls of roof and sides; the comparatively rapid progress of the workings, especially in a thin seam of coal, necessitating devices for a continual increase in the distance through which the power is transmitted. All these conditions, which in themselves vary widely in different mines, must largely influence the engineer in his choice of power.

As was to be expected, when labour-saving appliances were gradually making their way into favour, mining engineers chose the methods that were easiest in adaptation to existing plant and that cost least money to install. Such methods as pipe transmission of steam, rope transmission of power, and hydraulic pumping, were therefore the first that came to hand, as no special generating station was needed, and an old engine often sufficed for each purposed application of power. The idea of a generating station for the supply of power for all purposes was not thought of, or if thought of was dismissed, as the different appliances for the saving of labour were not all added at one time, but often separated by long periods of years.

It is never wise to attempt to transmit steam in pipes through any considerable distance. Condensation and consequent loss in efficiency will take place, however carefully the pipes may be covered with non-conducting material; and in mine work, especially in the working shaft, any part of the steam pipe which may have become stripped has often to wait a long time for repairs, little notice being taken so long as the engines below ground are kept running. Mining engineers are just waking up to the fact that an accumulation of small losses like this means in the year an appreciable diminution in

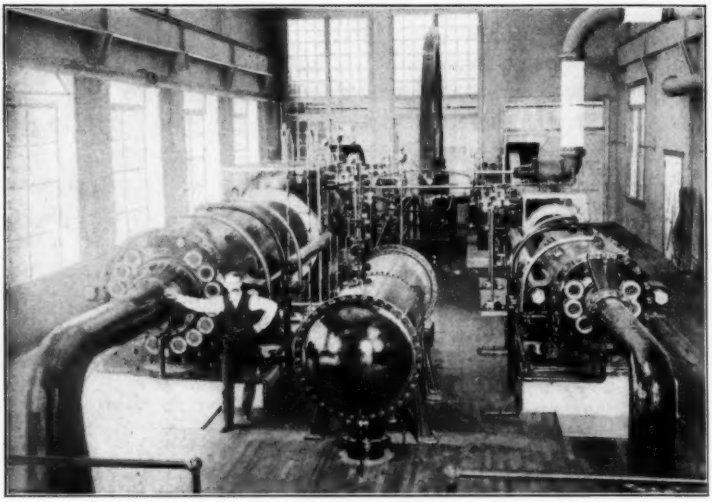
profits, and corresponding efforts are being made to reduce such leakage of power in working practice. The superheating of the steam enables it to be transmitted through pipes to a greater distance than is practicable in a saturated state, but even then not to such an extent as to warrant its transmission through any considerable length. In cases of necessity, however, superheating is an advantage, besides being in itself a source of economy in the working of steam engines. Too much anxiety should not be shewn to increase the efficiency of the pipe transmitter by superheating, as an overabundance of superheat is very injurious to the working parts of engines that are near the superheater, and speedily makes its effects apparent.

To demonstrate the effects of this appliance on the condensation of steam in pipes, the experiments made by Mr. Leach of Seghill Colliery are very apt. Dixon superheaters were fitted at the colliery a few years ago to a battery of five boilers, and whereas formerly 29.4 pounds of water per 100 square feet of pipe was collected from the steam pipes and traps, after the fitting of the superheaters to the boiler plant this quantity was reduced to 12.8 pounds. As an illustration of the economy effected, superheating has enabled Seghill colliery to be worked by three instead of four boilers, while still burning the same quality of small coal.

The limit of practical transmission of steam in pipes has probably been approached at Broomhills Colliery, Northumberland, where steam is conveyed to an underground pump 1,414 yards from the boilers. The drop in pressure is 13 pounds, and the loss by condensation 21.06 per cent.

As above mentioned, water, while used largely in slate and metalliferous mines for the production of power, relies on electricity or compressed air for the distribution of the power it has produced. As a transmitter of power, water has practically only one field of utility in a mine, viz., the pumping of water by means of a hydraulic pump to the main pumps, from a district lying to the dip. The high-pressure water for this purpose is led straight from the rising main to the hydraulic pump. Water is occasionally used to work hydraulic rams for the purpose of loading and unloading the cages, and for similar work, and in at least one instance for conveying coal some considerable distance through a large pipe.

Although in its main features there may at first sight seem but little reason why the power-generating station for use in a mine should differ materially from that which is designed to serve other utilitarian ends, such as the propulsion of cars or the lighting of a city, a little reflection will shew that if we confine our sphere of opera-



AIR-COMPRESSOR PLANT, HOMESTAKE MINE, LEAD, SOUTH DAKOTA.

Cross-compound Corliss type; steam cylinders 32 and 60 in., air cylinders 52¼ and 32¾ in., stroke 72 in.; 50 revolutions, 9,000 cu. ft. free air per minute, sufficient for 125 rock drills with steam at 125 lb. Several smaller compressors of the same make are installed. Ingersoll-Sergeant Drill Co., N. Y.

tions to one mine, considerable modification must be made in plant that would otherwise be suitable for propulsion or lighting. Taking a single large colliery:—it is probable that there exist few other works of similar extent in which the demand for power is so variable. In the pumping and ventilating alone do we find a uniform expenditure of power. All other engines, in point of size and importance, give way to the winding engine, which, especially in a deep mine, consumes a very large percentage of the total power generated. This engine creates at the beginning of every trip a demand for power which is greatly in excess of what it needs during the latter part of the trip, and this lesser demand is in its turn succeeded by a period of no demand. Again, breakdowns in the underground haulage system, and consequent spells of enforced idleness on the part of the winding and hauling engines, are fairly frequent, as is only to be expected in workings that are subject to unexpected falls of roof or sides.

In ordinary generating stations, such as would be designed for power-supply to large towns or railway companies, the favourite type of engine is probably the triple-expansion marine type, which is so constructed as to be eminently suited for economical working so long as the output is practically constant. The boilers are usually either

of the water-tube or cylinder marine type. The efficiency of these plants compares with that of the best marine practice, the steam consumption of which approximates to 2 pounds per indicated horse power per hour. When it is stated that the corresponding steam consumption of an ordinary colliery winding engine has been variously estimated at from 70 to 120 pounds, it will be seen that there is considerable scope either for the introduction of steam-economising appliances, or for a radical change in existing methods. The former have been for some years past in use in many mines in Great Britain, both in the form of feed heaters and steam superheaters. These justify their existence in that where they have been used they have certainly saved more than their cost and upkeep, but in themselves they are insufficient to work the good that could be wrought in conjunction with the latter.

If we extend our field of view, and include not one mine only, but a series of mines covering a broad area, a temporary stop at one mine will not affect the others, and the general effect will be a fairly uniform expenditure of power, and the more mines we include, the more uniform will the power expenditure tend to become. Practical application, however, involves the abandonment of existing steam plant which might otherwise have a long life before it, and the substitution of expensive leads and machinery for the distribution and utilisation of power, the effecting of which must be a gradual process and cannot but occupy a long period of time.

The type of engine most in favour in mine works for the purpose of power generation is the horizontal type, simple in the earlier, and compounded in the later examples. A typical instance is the electrical plant recently laid down for the Weardale Coal Co. This plant generates electricity for underground pumps dealing with a flow of 1,200 gallons per minute, against a head of 650 feet, and consists of a compound horizontal steam engine of 600 horse power, driving by means of ropes the dynamo, whose output is 400 kilowatts. The generator is of the continuous-current type, having a central driving pulley, by which arrangement either half of the machine may be worked separately. A plant of larger size is that at the Staveley Coal and Iron Co.'s works, where the aggregate horse power of the power-generating stations at the five collieries is 3,500, most of which is employed in operating polyphase induction motors situated in all parts of the mines, surface and underground. A modern plant of a most comprehensive type is that installed by the United States Coal and Coke Co., which consists of two cross-compound engines of 1,200 horse power each, driving two 750-kilowatt 6,000-volt generators, with

a 50-kilowatt exciter set. There are four additional sub-station equipments, and nine induction motors for driving fans and pumps; also five mine locomotives, and sixteen electric motor outfits for coke oven larries. In the Homestake mine, Black Hills, South Dakota, is a fine air-compressing plant, supplying power to the motors driving the ore trains. Besides this, in the rock beneath the floor of the hoist is a huge excavation, 75 feet by 35 feet, for one of the largest air-compressors yet built by the Ingersoll-Sergeant Co. The duty of this plant consists in operating 125 rock drills, and a battery of eight 200-horse-power boilers is required for its working. (See page 648.)

Choice of power transmission depends on initial cost, cost of working and keeping in repair, and efficiency. In mine work the last item must be taken in its broadest sense, including not only a fair output of power for a given coal consumption in the boilers, but also the ability to overcome when necessary—and not infrequently—a resistance greater than the average. For this end the whole of the plant, generator or compressor, conductors, and motors, should be "well up to" their work, a phrase that in mining parlance means roughly anything up to 50 per cent. ahead of it. Naturally, in point of efficiency as efficiency is usually considered, such a plant does not compare with one that is designed and laid down with a view of an assured uniform output, but under conditions such as obtain in ordinary mine work ensures the cost of upkeep and repairs being kept within bounds. So far as actual efficiency in transmission is concerned over ordinary distances, electricity is preferable to compressed air, though the difference becomes less marked as the distance of transmission becomes greater. On the other hand, compressed-air motors are generally simpler to understand and repair than electrical, and the fitting in of spare parts can easily and cheaply be effected in the mine. The joints of compressed-air mains, however, are liable to leakage, and the splitting of the main into several channels is not so simple a matter as in the case of electricity. A useful combination is often resorted to. Electricity is transmitted into a mine so far as is thought convenient or safe, and at this point an electrical air compressor is placed, which supplies power to machines situated further in the mine. Thus two purposes are served. The economical transmission of power by electricity is effected, and the use of compressed air is secured in parts of the mine that might threaten danger to the use of electricity, or in machines that do not adapt themselves to electrical power.

The extensive use of electricity underground in mines, especially in coal mines, is largely limited by the fear of accidents arising from its use, which may involve serious expense if not loss of life. The

main cables must pass down the shaft and along galleries in which the available space is necessarily limited, and the permanence of the cable insulation constantly threatened both by atmospheric conditions and by possible falls of roof and sides. Other incidents, too, which are inseparable from the use of electricity, may under certain conditions prove a source of very grave danger. The occurrence of a spark in a suitable mixture of gas and air would cause an explosion, and although enclosed motors may be used, it is possible that rough usage received in the mine may impair the efficiency of the air-tight chamber, in which case the feeling of security engendered by its use may prove the greatest source of danger. It has been suggested as additional security, to keep the air-tight chamber full of carbonic-acid gas.

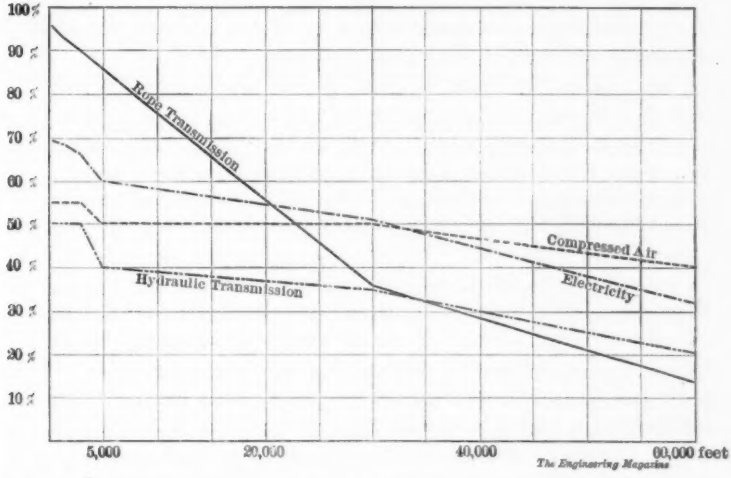


DIAGRAM SHOWING COMPARATIVE EFFICIENCIES OF VARIOUS METHODS OF POWER TRANSMISSION THROUGH VARYING DISTANCES. (BERINGER.)

Armouring the cable is commonly practised in order to save the insulation from small damages, but in case of an injury piercing the insulation a flash results before the fuses blow. If the cable is unarmoured there is no flash, but unless the leakage is detected smouldering may result. The insulating material for mine cables should be flexible and waterproof, and durable under varying conditions of atmosphere and temperature. A substance that has found much favour in mining circles is that known as dialite, a species of vulcanised bitumen. A feature that especially recommends it to miners is the ease with which a damaged portion can be repaired. The insulation

is cut away for a few inches on each side of the injured part, and a fresh lapping made, which can be vulcanized *in situ.*

On October 16, 1902, a departmental committee was appointed by H. M. Home Secretary, to enquire into the use of electricity in coal and metalliferous mines, and the dangers attending it, and to report what measures should be adopted in the interests of safety by the establishment of special rules or otherwise. This committee concluded their enquiry in May, 1903, and submitted as their finding the following four general principles which should govern the employment of electricity in mines:—

1.—The electric plant should always be treated as a source of potential danger.

2.—The plant, in the first instance, should be of thoroughly good quality, and so designed as to insure immunity from danger by shock or fire; and periodical tests should be made to see that this state of efficiency is being maintained.

3.—All electrical apparatus should be under the charge of competent persons.

4.—All electrical apparatus which may be used when there is a possibility of danger arising from the presence of gas, should be so enclosed as to prevent such gas being fired by sparking of the apparatus; when any machine is working, every precaution should be taken to detect the existence of danger, and on the presence of gas being noticed, such machines should be immediately stopped.

In addition to the above, the committee drafted a list of special rules which they thought might with advantage be introduced into all mines. These, however, have not met with approval amongst the leaders of the mining industry. It is a well-nigh impossible task to draft a set of rules governing the use of electricity which shall be applicable to the varied conditions to be met with in the coal and metal mines of Great Britain; and further, the introduction of any rule granting, for instance, an arbitrary power to a district inspector of mines to place a veto on the existing method of electrical employment or transmission in any portion of a mine, would tend to extra diffidence and caution on the part of the management in placing orders for a new installation on a large scale. And they are cautious enough already! It should be sufficient to allow the mining engineer the same latitude of judgment as he already possesses in the matter of the installation of compressed-air or steam plants, knowing that he is directly responsible for the safe and efficient working of all apparatus under his charge, and for his own sake will not be likely to employ any agent that may create a tendency to danger in the conditions obtaining in his mine.

THE DEVELOPMENT OF ECONOMY IN RAILROAD TRANSPORTATION SINCE 1875:

By S. Whinery.

The railway was one of the first mechanical-transport agencies to attain commanding importance. It remains one of the most impressive, and perhaps the most influential of all, today. It seems appropriate, therefore, to sum up this number by a review of the advance in economy in railway transportation which has accompanied the other developments studied in preceding articles. We are especially glad to have placed this closing article in the care of one who has himself taken so active a part in the extension of American railways and in their betterment.—THE EDITORS.

THE writer who, in a single magazine article, attempts to delineate the progress of railroad development during the last generation, must necessarily work with broad lines and scant attention to detail. But he is confronted by the fact that the history of this important department of our industrial activity during that period is mostly a history of details. Wonderful as has been the development and expansion of our railroad system since 1875, there have been no epoch-making discoveries or improvements in railroad construction, equipment, or operation. Progress has been rather through the gradual but unremitting development and improvement of the theories and appliances that were then already familiar in the railroad world.

In 1875 our railroad system was not yet half a century old. At the beginning of the preceding generation (1843) there were only 4,185 miles of railroad in the United States. But that generation was one of unparalleled activity and expansion, not only in the growth of the railroad system, but in the development and application of the fundamental principles of railroad transportation and of the physical plant best adapted for the requirements of the business.

In 1875 the necessity for better permanent way, for lighter grades and easier curvature, for more powerful and economical locomotives, for cars of greater capacity, and for improved operative methods, was understood and appreciated. Steel rails had already been introduced, and modern standards of track construction and maintenance were coming into use; the leading types of our present locomotives were already in service; cars differed from present practice mostly in their lesser size, strength, and capacity; the sleeping car was in successful operation, and the refrigerator car was not unknown; the air brake had been developed and largely applied to passenger equipment, and

its later use on freight trains was foreseen and predicted; the prototypes of our present signaling systems had appeared, and the methods of train operation now in vogue, were in process of development. On the economic side the disastrous effects of unbridled competition had already become manifest, and able minds were engaged upon the problem of controlling it within reasonable limits; and projects for consolidating connecting lines into systems under one management were being cautiously worked out. In short, the foundation and framework of our present railroad practice had been so successfully established that the succeeding generation has been devoted to developing and perfecting the superstructure.

Railroad transportation being a commercial business, the ultimate object of those engaged in it has been to make it profitable, or, in other words, to increase earnings and cut down expenses. Actually, the problem has been largely how to reduce the cost of railroad transportation. Upon this problem has been engaged the ablest body of men that any country has ever marshalled in any single calling. They have labored with a devotion and unity of purpose, the like of which it is hard to match in the history of the world. They have not worked singly and independently, but unitedly through systems of organization that are themselves unparalleled outside of military history and discipline.

In 1875 there were 74,096 miles of railroad in operation in the United States, together with probably from 15,000 to 16,000 miles of sidings, second and other subsidiary track. In 1903 the number of miles of railroad operated in the United States was 207,784 and the number of miles of subsidiary track was 79,376. The mileage of track was thus, in twenty-eight years, multiplied by three.

Improvement in railroad transportation has not been confined to any one department of the business, nor has it been especially more marked in one department than another. Permanent way, equipment, and operation are necessarily so intimately related to each other that they must advance concurrently and harmoniously or not at all. Without increased strength and stability of track and other permanent-way structures, the employment of the present heavy rolling stock and high speeds would have been impossible, and without improved operative methods, improvements in permanent way and rolling stock would have proved largely futile.

Reviewing briefly the measures and steps by which this result has been achieved, we may begin with the essential foundation of the modern railroad—the permanent way. From the mechanical point of view the cost of hauling a car over a railroad is affected by two ele-

ments; the resistance to movement of the car, and the efficiency of the locomotive. Upon a straight and level track the power required to move a car need be sufficient only to overcome the friction of wheels upon rails, of car journals in their boxes, and the resistance of the air. To reduce to a minimum the frictional resistance between the wheels and rails requires that the rail shall have such strength and rigidity that it will not yield under passing loads, and that it be firmly supported by the substructure of the track.

The substitution of steel for iron rails, which took place rapidly during the earlier years of the period we are considering, and which was greatly accelerated by the rapid decline in the price of steel, was one of the most important advances in modern railroading. In 1875 the market price of Bessemer steel rails was $75 to $80 per ton; in 1880 the price declined to about $65, and at the present time it does not exceed $28 per ton. One of the contributing causes of this rapid decline in prices was the general adoption about 1893 of standard rail sections. Previous to that time, when many of the roads demanded rail sections of special design, the variety of forms called for was very great, and as special rolls had to be provided for each different section, more or less delay and increased cost resulted. To-day about three-fourths of all the rail produced in the United States conforms to the standard then adopted. As the weight of locomotives increased, heavier and stronger rails became necessary. In 1875 very few rails weighed over 60 pounds per yard; to-day the weight ranges from 80 to 110 pounds per yard. These changes called for a corresponding improvement in other track appurtenances. Heavier and stronger rail joints were provided, the quantity and quality of ballast was increased, more attention was given to drainage, and greater care was taken to place and maintain the rails in good line and surface. The substitution for wood, first of iron and then of steel, in the construction of railroad bridges, developed very rapidly, and important improvements in the general design of these bridges were made in the early part of the period. Concurrently, improvement was made in the form and tread of car wheels and in the dimensions, workmanship, and means of lubrication of axle bearings. All these improvements resulted in a considerable reduction in the frictional resistance of rolling stock, as well as in reduced cost of maintenance.

But only a small part of any railroad line can usually be straight and level, and any departure from that condition introduces other and very important elements of resistance—curves and gradients. As is well known, the resistance offered by curves varies with their radius and length, while that of gradients varies as the steepness of the in-

cline. To move a ton on straight and level track may require a pull of from 7 to 10 pounds, and a curve having a radius of 400 feet may double the power required. To move a weight of one ton up a gradient of one per cent requires a pull of 20 pounds regardless of frictional and curve resistance, so that a gradient of one-half of one per cent, or about 26½ feet per mile, at least doubles the resistance due to friction alone.

The importance of easy curves and light grades, not fully appreciated when the earlier roads were built, became more and more apparent as the business of the roads increased. When it is remembered that with equal frictional resistance, a locomotive will haul three times as many tons with no greater expense over a level track as over one having a gradient of one per cent, the economic importance of light grades may be appreciated. It must be remembered, too, that grade resistance is as immutable as the force of gravity, and that no amount of mechanical skill or operative ability can avail against it. To lift cars to a certain elevation demands a definite quantity of mechanical work, and the cost of this work constitutes a fixed charge on the resources of a road, more inexorable than the interest on its bonded debt. It is not surprising, therefore, that an increasingly large part of the money spent upon our railroads for general betterments in the last twenty years has been devoted to reducing gradients, even to the extent of an entire change in the location of considerable portions of the line. A notable example may be mentioned. The Pennsylvania Railroad between Philadelphia and Harrisburg was originally located and operated without much regard to sharpness of curves and steepness of grades. But as the business of the road grew and the limiting effect of these grades and curves became more apparent, reconstruction and relocation of the line were resorted to and steadily continued, until today not a single foot of the original line remains in operation.

Terminal facilities and appliances for handling freight, which may be mentioned in connection with permanent way, have not only been greatly enlarged and improved, but the introduction of labor-saving machinery has materially reduced the cost of conducting the business per unit of freight handled. This is more particularly true of bulky freight, such as coal, ores, and grain.

Track signal devices may also be appropriately considered in connection with permanent way. The general adoption of automatic signaling systems for controlling the movement of trains deserves to be classed as one of the most important improvements made in modern railroading. If the present practical railroad man were asked

what have been the two most important advances in railroad operation in the last twenty-five years, he would doubtless name the application of the air brake to freight trains and the adoption of automatic signaling, since they together have contributed, more than any other improvements, to speed and safety in operating trains.

Improvements in rolling-stock equipment have had two main objects in view; to increase the capacity and working efficiency of both cars and locomotives, and to increase the ratio of paying to dead load hauled over the lines.

In locomotives the most notable development has been in size and hauling capacity. In the seventies passenger locomotives weighing 35 tons and freight locomotives weighing 45 tons were considered notable; to-day passenger locomotives weighing 60 tons and freight locomotives weighing 85 tons are not sufficiently uncommon to provoke comment. The average weight of locomotives has, probably, since the former period, increased from 60 to 70 per cent, and their hauling capacity has increased in a still larger ratio. Regardless of size, the locomotive of today is a much more effective machine than was its predecessor of thirty years ago. Scientific designing and careful attention to every detail has increased its mechanical efficiency in every direction. Among the more notable improvements have been the development of practical forms of the compound locomotive engine, the use of balanced slide valves, fireboxes designed to burn more efficiently the particular fuel available, boilers utilizing more fully the heat of the fuel, more careful balancing of driving wheels, and better designing of every part so as to secure the greatest attainable strength and endurance.

In general design, cars of the various kinds do not vary greatly from the types that were in use thirty years ago. The important changes have been in strength and carrying capacity, in the substitution of iron and steel for wood, and in the development of details. In 1875 the freight car weighed from 9 to 10 tons and carried loads of 10 to 11 tons. Only about one-half the total load of such a car yielded revenue. To-day the average weight of freight cars probably does not exceed 15 to 16 tons and their average load capacity is about 30 tons, while about one-seventh of the box, freight, and coal cars in use have load capacities of 40 tons or more. The more recent standard steel coal and ore car weighs 16½ tons and carries a load of 50 tons, or about three times its own weight.

Perhaps the most important advance that has been made in freight equipment has been the quite general application of automatic air brakes to freight trains, which has made possible much higher speeds

and greater safety in operation. Like the nimble penny, it is the active car that brings in a satisfactory revenue. Thirty years ago 12 to 15 miles per hour was considered the highest economical speed for freight trains; today double that speed is considered quite practicable, and through continental trains with perishable freight may average nearly that speed throughout the whole trip. Obviously if a car can be made to make two trips where it formerly made one, its profit-earning capacity must be greatly increased. The quite recent introduction and general application of standard automatic couplers has also promoted higher speeds and greater safety of operation.

One of the most important results of these physical improvements in track and equipment has been the reduction in the relative cost of the human labor necessary for the operation of trains. Reliable statistics upon this point do not extend back very far into the past, but their lesson is interesting. In 1892 the wages paid in the United States to conductors, enginemen, firemen, and trainmen amounted (roughly estimated) to about $128,000,000. The freight handled that year was equal to 88,241,000,000 tons carried one mile, and the passengers equal to 13,363,000,000 carried one mile. If we consider a passenger as equivalent to a ton of freight, the total ton-mileage in that year was 101,604,000,000, and the ton-mileage per dollar expended for wages was 794. In 1903 the sum paid to the same classes of employees was $207,812,281, and the ton-mileage per dollar of wages paid was 934, an increase of over 17½ per cent, notwithstanding the fact that the rate of wages paid had, in the meantime, increased fully 8 per cent. This lower labor cost has been made possible largely by greater train capacity, which in turn has resulted from the improvements to which we have referred. In 1875 the average train load of freight seems not to have exceeded 150 tons, while in 1903 it was 310 tons, so that in that period the average freight-train load has been more than doubled.

The effect of better permanent way and more substantial equipment has had another permanent effect worth noting—the decrease in the cost of maintenance and repairs of equipment. The data for accurate comparison are wanting for the earlier period, but an example will serve for illustration. In 1870 the cost of locomotive repairs on the Pennsylvania Railroad was 9.13 cents per mile run by locomotives, while for the year 1902 the cost of the same item was 6.94 cents. Doubtless something like the same relative reduction in the cost of maintaining other rolling stock has taken place during the period. When it is remembered that the total expenditure for maintenance of equipment on all the roads of the United States for

the year 1902 was about $213,000,000, some idea may be formed of the saving that must have resulted.

Turning from the physical to the operative side of the subject, we shall find that improvements and advances in the operation and management of railroads have kept pace with those of track and equipment. Space permits only the briefest reference to this department. The results have been due mainly to better organization, to stricter and more intelligent discipline, and to the simplification and standardization of methods of conducting the business.

At the beginning of the period we are considering the era of railroad combinations had fairly begun. Some of the more important companies had for years been gathering together branch and connecting lines and consolidating them into single systems under one general management. But the gigantic combinations of the present day had not been dreamed of by the public, though they seem to have been vaguely anticipated by some of the far-seeing railroad men of that time. Whatever may be said otherwise of these great consolidated systems, there can be no doubt that they have had an important effect in reducing the cost of transportation, as the result of harmonicus management and operation—the subordination of the individual and local interests of the constituent roads to the general interests of the whole system, the maintenance of rates, the avoidance of terminal delays, of complications and expenses at connecting points, and, to a certain extent, a relative reduction in the amount of money paid for wages and salaries. It is doubtful, however, if the last named item is as important as the public seems to believe. While consolidation has dispensed with a large number of general officers, it has been accompanied by an increase in the salaries of those who have remained, commensurate with their larger responsibilities; and the number employed in the lower ranks, never more than the work demanded, has probably not been relatively decreased.

The effect of larger capitalization in the general reduction in cost of railroad transportation cannot be overlooked. In the earlier history of American railroads, when the country was less wealthy and surplus capital was comparatively scarce, it was not always possible to obtain the money with which to make improvements, even when it could be conclusively shown that additional investment might be made to yield better returns upon the whole capital. Railroad managers were compelled to "cut the coat according to the cloth," and the result was often far from satisfactory. Today, conditions have greatly changed. Surplus capital is comparatively abundant and the question has become not so much, can needed capital be obtained, as

can it be profitably employed. The management that can demonstrate that an additional dollar can be made to yield good and certain returns, has little difficulty in obtaining that dollar, or any multiple of it. However urgent and profitable have been the physical improvements of our railroads, not so many of them could have been consummated without the bringing in of additional outside capital. As a rule it can be said that additional capitalization has been wisely administered and has resulted beneficially to the public at large.

What has been the net result to the public and to the owners of the railroads of all these extensions and improvements of our railroad system in the past twenty-eight years? The popular belief seems to be that the railroads have reaped the chief benefit, but the facts do not support such a contention. The rates charged for railroad transportation have largely declined and the public has greatly profited thereby, but the returns to stockholders have also declined very materially. Sufficient data are not obtainable from which to determine the average railroad freight and passenger rates in 1875, nor in fact with satisfactory accuracy, at the present time; and space will not here permit the mention of enough illustrative examples to be of value in forming conclusions; but it is probably quite safe to say that, during the period, passenger rates have declined one-third and that freight rates have been practically cut in two.

In 1875 the average revenue derived from hauling one ton of freight one mile on four of the leading railroads of the country was 1.16 cents, and the average for the whole country was probably considerably higher, while in 1903 the same item averaged, for all the railroads in the United States, 0.763 cent, indicating a decrease of about 34 per cent.

In 1875 the total outstanding capital stock of the railroads in the United States was $2,248,358,375, and the amount paid in dividends upon this stock was $74,294,208, or 3.30 per cent. In 1903 their total capital stock was $6,270,032,728 and dividends to the amount of $166,176,586 were paid, an average of 2.65 per cent, being a net reduction during the period of about 20 per cent.

It is true that rates of interest have also materially declined during the period and lenders do not now expect the same returns from capital that they did a quarter of a century ago, but a careful study of all the facts seems to justify the conclusion that railroad investments, whether in bonds or stock, are not relatively more profitable today than they were then.

EDITORIAL COMMENT

PROFESSOR BURR'S important article upon the present aspects of the Panama Canal work, which leads this number, marks a stage in the second great era of progress toward the opening of an interoceanic waterway—the era of actual construction. When THE ENGINEERING MAGAZINE took up the battle, nine years ago, the fight was all against the fatal error—seemingly almost inevitable—of a National commitment to the Nicaragua project, saddled further with the load of the company then exploiting the concession. The course of that battle, the succession of arguments and demonstrations by the foremost engineers of the world which we had the honor of presenting through these pages, and by which public and official opinion and judgment were moulded toward the right decision—these we reviewed editorially not long since. Now that the route is assured, the interest lies in the determination and selection of the best possible plan, and the execution of that plan by the best possible means.

* * *

CONCERNING both plan and means we may well for the present hold an open mind, waiting the completion of the studies now in progress and clearly outlined by Professor Burr. The thoughtful reader will find, in the reflections awakened by the reading of his article, many points suggestive of the great lasting advantage of a sea-level canal. Not the least is the difficulty of anticipating and providing for the requirements of the sea-going craft of even the next few years, in the matter of draft and other dimensions affecting the design of locks. But the difficulties of this decision are by no means evaded by adopting a sea-level plan. The tide lock on the Pacific side, necessary even with a sea-level canal, and the depth of the canal section throughout—what dimensions shall be adopted for them as sufficient for "the largest ships afloat?" How many more years and millions can be wisely spent in the undertaking to free the canal from such restrictions to navigation as would be imposed by locks and a summit level, and what other restrictions would have to be accepted in compensation? We are inclined to think these are the considerations upon which the decision should finally be made; for in spite of much current report, a perfectly safe foundation for the necessary dam can be secured without going to bed rock, if the high-level plan be otherwise deemed the most desirable.

* * *

THE sea-level plan was de Lesseps' ideal, and has been admitted to be the ultimate goal of the project by many of its advocates. And if it is indeed the most desirable waterway for large shipping, it is well to recall to mind now that no sea-level canal could ever have been built on the Nicaragua route. If unfortunately we had attempted the other scheme, and found (as there was every indication we should find) that neither at Ochoa nor elsewhere could foundations be secured for the dam which was the key to the Nicaragua line, the alternative would not have been a greater outlay for a proportionately better result; it would have been the collapse of the entire undertaking, and the loss of everything that had gone into it. And from that disastrous

experience we are convinced the country was saved by the patient, persistent, and triumphant fight made for the adoption of the Panama route.

* * *

THE recent meeting of the American Society of Mechanical Engineers in New York proved to be a very satisfactory one, both from a professional and a social point of view. The papers presented, some of which have been noticed elsewhere, bore upon existing and future matters of engineering work in such a manner as to elicit interested and valuable discussions, and both as regards attendance and activity the meeting may be classed as one of the most successful which has yet been held. Apart from the professional papers, and the discussions upon them, we may note the interest which attaches to certain of the reports of the various committees.

Thus the status of the new Union Engineering Building was set forth as being in a satisfactory condition. The ground has been cleared, the various legal matters in connection with the formation of the holding corporation have been arranged, and the detailed plans for the structure are in an advanced state of preparation, so that the letting of the contracts is the next step in the prosecution of the work. The portion of the building to be occupied by the combined libraries of the several societies has been given especial attention by a joint committee, composed of members of the American Institute of Mining Engineers, the American Society of Mechanical Engineers, and the American Institute of Electrical Engineers, and this committee has held monthly meetings since the time of its appointment for the purpose of discussing the various details of the arrangement of what, it is hoped, will become the greatest engineering library in the United States.

As twenty-five years have elapsed since the foundation of the Society, a historical committee has been appointed, and has been actively engaged in collecting data and information relating to the early history of the organization. It is evident that this work has been commenced none too soon, since much interesting matter might otherwise have been lost. It is still desirable to add to the material which has already been gathered, and the committee is most desirous of procuring from any of the members who attended the preliminary meeting at the old office of the *American Machinist* on February 16, 1880, any notes or matters of interest relating to that historic event.

The later history of the Society is recorded very fully in the volumes of its Transactions, but few could foresee, at the date of the formation of the original gathering, the important results which were to flow from that meeting, and hence many things were overlooked in the early records which it is now most desirable to replace, and in this important work the aid of all the members should be enlisted.

* * *

AMONG the matters of current importance brought before the meeting should be noted the plea advanced by Col. E. D. Meier for the continuance of the work of the coal-testing plant, begun at the St. Louis Exposition, and now under consideration as an applicant for an appropriation of $100,000 by Congress. The immense importance of this study, and the fact that in no other way can an acceptable record of the heating value of American coals be secured, renders it extremely desirable that this appropriation be made. We desire here to record the emphatic endorsement of the Magazine to this work, under the full conviction that it will return to the nation many times the value of the moderate appropriation requested.

REVIEW OF THE ENGINEERING PRESS.
"THE WORLD IS ITS FIELD"

THE COST OF PRODUCTION.

THE INFLUENCE OF THE REDUCTION OF COST OF ARTICLES OF CONSUMPTION UPON THE PROGRESS OF CIVILISATION.

Alexander Siemens—Institution of Electrical Engineers.

THERE is becoming evident in all departments of industrial work an increasing appreciation of the interdependence of the various factors which go to make up modern civilised activity. Formerly the capitalist, the business manager, and the engineer each had his own department of work, and meddled, if we may use the word, but little with the fields of the others. To-day we find that the engineer is extending the methods of mechanical and physical science to the departments of finance and administration, and the results are becoming daily apparent.

In his inaugural address before the Institution of Electrical Engineers, Mr. Alexander Siemens discusses this important subject, his views attracting much attention and favorable comment.

Considering the features of modern civilisation generally, it must be acknowledged that its true foundation lies in the lowering of the cost of production, that is, that the progress of civilisation is in proportion to the cheapening of the articles of consumption.

"Although this may sound purely materialistic, the process of lowering the cost of production, which implies the employment of all the knowledge we can acquire, and of all the training the best schools can give us, results in greater ease of acquiring the necessaries for keeping alive, and therefore it gives us more time to cultivate other aspects of our existence. This general principle has manifested itself as much in the electrical industry as elsewhere, and further progress appears to be dependent on further lowering of the cost of its products. When we come to inquire into the means for carrying out this principle we soon recognise that the solution of the problem depends upon a variety of circumstances which all influence the result, although they may be investigated and discussed separately.

"For internal working every industry depends upon three principal factors: (1) the capital which provides the works and the raw material; (2) the workman who converts the raw material into the finished product; (3) the management. It is quite idle to try to establish the relative importance of these three factors, for each one is indispensable, and likewise the prosperity of each one is inseparable from the prosperity of the others; so that no industrial establishment can flourish where these three factors do not co-operate heartily and harmoniously. As a first condition for further progress we should in fact, recognise the identity of interest between the capitalist, the workmen, and the management, as any measure which is intended to unduly favour any one of these three factors would inevitably increase the cost of the product beyond what it ought to be and thereby restrict its sale, thus damaging all three. When we examine in detail in what way each of the three factors can contribute to the lowering of the cost of production, we find ample confirmation of the intricacy of the problem."

The share of capital in the value of the finished product is proportionate to the cost of the depreciation and maintenance of the works and outfit, the cost of raw materials,

and to the interest on the investment, represented by profit. It is evident that the first item is greatly affected by the skill with which the establishment has been planned and equipped, a matter largely in the control of the engineer. The question of the cost of raw materials is dependent to a great extent upon fiscal questions in the country in which the undertaking is carried on, and it should be remembered that practically there is no such thing as an absolute raw material, the raw material of one industry being the finished product of another, but it must be realised that the cost of materials should be kept as low as possible, and that every increase in this item is a hindrance to the development of the industry.

So far as profits are concerned, their rate is naturally dependent upon the interest-earning power of money in other parallel lines of investment, but the actual amount to be charged to the industry on this account is directly dependent upon the capitalisation, so that it is important to avoid burdening an undertaking with more capital than is required for setting it up as a going concern and for providing a reasonable amount of working capital.

"When considering the influence of the second factor—the workman—on the value of the product, it becomes clear very soon that the amount of work turned out in a given time has a twofold influence on the result, as the time occupied in producing an article not only regulates the amount of the wages, but also the proportion of the dead charges to be debited to the article. It is, therefore, quite certain that in order to contribute his share to the lowering of the cost of production of an article the workman has to turn out a greater number of these articles in a given time, and the problem is how to attain this object without endangering the interest of any one of the three principal factors. This sounds almost as if slave labour would prove an economic plan in the carrying on of industries: it can, however, hardly be contended that the interest of the workman is considered under such conditions, and for this reason alone it should be condemned, even if there were no other objections to it.

"There are, however, legitimate ways in which the amount of wages to be charged against an article can be diminished. Most important among them is the substitution of machine work for hand labour, and where this is done, unskilled labour should be utilised for running the machines under the supervision of a few skilled artisans. Here, again, the interests of the workman appear to suffer, and whenever he is confronted with a new labour-saving machine he airs his old grievance that machines will deprive the workingman of his living, just in the same way as he opposed the use of all machinery a hundred years ago. The lesson taught by experience has evidently not made an impression; but nobody can deny that, instead of making skilled labour superfluous, the introduction of machinery has resulted in more skilled workmen being employed, and at better wages than before, and similar developments are likely to follow when the workman is further relieved from hard toil by his best friend, the labour-saving machine. Another feature of machine work is the greater accuracy that can be attained, so that, while the cost of production is lowered, the quality of the product is improved, and at the same time the interchangeability of parts is secured, which in itself contributes to the lowering of cost. It is not easy to convince workmen that 'increase of output' is of advantage to them; if we are to accept statements published in the newspapers, they rather believe in the direct opposite, 'restriction of output,' although their official organs repudiate the idea."

Taking up the question of management and its influence on the cost of production, Mr. Siemens considers it as including: the selection of the site for a works, their planning and equipment; the commercial work connected with the business; the arrangements for carrying on operations; and the investigation of new methods of manufacture. Although the engineer is gradually entering upon the conduct of the first three of these departments, Mr. Siemens considers principally the last, showing the rules which should govern the designing of apparatus and the development, by experimental investigation, of new methods of work. In doing this he addresses particularly those who have recently been graduated from technical colleges, showing the desirability of their acquiring by experience the nature of the practical difficulties to be overcome.

"It is not so important that they learn to overcome these difficulties as easily and as quickly as a skilled workman, but that they acquire the habit of thinking how to avoid these difficulties when they are designing new work, and how to take advantage of the material at their disposal. In other words, a designer should have an intimate acquaintance with the scientific principles that come into play and with the ways in which they are applied, and he should know, if possible from personal experience, the capabilities and the limitations of the workman and of the machinery by which the operations are carried out. It is, however, by no means sufficient for preparing suitable designs to be well acquainted with the means employed to executive them; it is just as important to form an accurate conception of the problem that has to be solved, and to possess a thorough knowledge of previous attempts in the same direction, and of the causes of their success or failure.

"Another branch of knowledge required for the good management of factories is a careful training in the way of conducting experimental investigations, coupled with the good judgment as to which investigations are worth taking up. No doubt the list of qualities that ought to be found in a good manager could be extended still further, but enough has been said about all the three principal factors to show the great number of different points which have to be considered in connection with the internal working of modern industries. Besides these internal factors, there are all the external circumstances which influence the well being of the industries, and it is easy to see, even without entering at length into further details, that no true picture of the state of an industry can be arrived at if only a few features of their complicated constitution are to be taken into consideration."

Mr. Siemens concludes his address with a reference to the influence of standard systems of measurement, such as the metric system, upon the reduction of the cost of production, together with the effect of patent protection upon the development of industries, and the whole forms a very interesting and instructive paper.

SOME REFINEMENTS OF MECHANICAL SCIENCE.

ACCURATE METHODS OF MEASUREMENT AS APPLIED TO THE DIVISION OF TIME, ANGLES, AND LINES, IN PRACTICAL WORK.

Ambrose Swasey—American Society of Mechanical Engineers.

FOR a number of years it has become a custom in the American Society of Mechanical Engineers for the retiring President to select for the subject of his address some topic of engineering work with which he has been closely identified in practice. This excellent practice has resulted in producing, instead of the somewhat trite and stereotyped essay commonly suggested by the term "presidential address," a monograph upon an important department of engineering work, by an acknowledged specialist, and the *Transactions* of the Society have been correspondingly enriched.

At the recent convention of the Society Mr. Swasey chose as the subject of his address the matter of some refinements of mechanical science, and those who know of the remarkable work which has been done by Mr. Swasey and his associates in the adaptation of the precise methods of the laboratory to the workshop will realize the value which must attach to an address upon the subject from such a source.

Mr. Swasey takes up first the question of the division and measurement of time, discussing first the historical side, and following with some interesting notes about the accuracy of modern timekeepers.

"Galileo's beautiful discovery of the isochronism of the pendulum from the swinging chandelier in the church at Pisa, was of great value in many respects, but in none more so than in its application to the measurement of time.

"Soon after that great discovery the English clock-maker, Graham, invented the mercurial pendulum, by which the variation in its length caused by the difference in temperature was fully compensated, and some years later Harrison, another English

clock-maker, invented a compensating pendulum, which consisted of a series of metal bars having different coefficients of expansion—so that two hundred years ago, as it is to-day, the pendulum was the nearest perfect of all the devices that have been employed for governing or controlling the motions of a clock mechanism.

"Every part of the clock down to the minutest detail has been the subject of study and improvement, and they are made and adjusted with such precision and delicacy that in testing them the question is, within how small a fraction of a second will they run. Not content with their marvelous performance when under normal conditions, some of the finest astronomical clocks are surrounded by glass or metal cases, in which a partial vacuum is maintained, and in order that the cases may not be opened or disturbed, the winding is done automatically by means of electricity; the frequency of the winding in some cases being as often as once every minute. These clocks are set up in especially constructed rooms or underground vaults, where they are free from jar or vibration, where the temperature and barometric conditions remain practically constant, and where every possible precaution is taken to further minimize the errors of the running rate.

"A clock in the observatory at Berlin has run for several months under these favorable conditions, with a rate having a mean error of but fifteen one-thousandths of a second per day and a maximum error of thirty one-thousandths of a second per day.

"Another clock installed at the observatory of Case School of Applied Science at Cleveland, running under similar conditions, also has a mean error of fifteen one-thousandths of a second per day, with a maximum error for several months of but twenty-two one-thousandths of a second per day.

"These are notable examples of the present state of the art of clock-making, and show the wonderful precision with which minute intervals of time can be measured."

Passing to the subject of the division of the circle, Mr. Swasey shows how the improvements in machinery and methods of graduation have made it possible to produce upon small circles graduations far more accurate than were possible upon the large circles used down to the close of the 18th century. At the present time the more modern astronomical instruments are provided with graduated circles of thirty inches in diameter and under, the reading being done with the aid of microscopes, and fractions of a second being easily read.

In connection with the question of meas urements of length, the dividing engine of Professor Rowland is stated to be the most accurate, diffraction gratings having been ruled upon it as fine as 43,000 lines to the inch, with a maximum error of one-millionth of an inch.

"The production of these gratings, which has enabled the physicist in his study of the spectrum to enter fields of research before unknown, has not only called for the highest degree of perfection ever attained in the spacing of linear distances, but it has also called for a refinement most difficult in the optical surfaces upon which the lines are ruled. To Mr. Brashear was given the problem of producing such surfaces, and notwithstanding the many difficulties encountered in working and refining the speculum metal plates, he has made many hundred plates with surfaces either flat or curved with an error not to exceed one-tenth of a wave length of light, or one four hundred thousandth of an inch.

"The established standards of length which are the yard of Great Britain and the meter of France, being made of metal, and liable to destruction or damage, Prof. Michelson conceived the idea of determining the lengths of these standards in wave lengths of light, which would be a basis of value unalterable and indestructible.

"For the purpose of carrying out these experiments, the interferometer was constructed, an instrument which required the highest order of workmanship and the greatest skill of the optician. Again Mr. Brashear proved to be equal to the occasion, and made for the instrument a series of refracting plates, the surfaces of which were flat within one-twentieth of a wave length of light, with sides parallel within one second. This was the most difficult work ever attempted in the refinement of optical surfaces.

"Professors Michelson and Morley devised a method for using the interferometer

for making the wave length of some definite light an actual and practical standard of length. So satisfactory was the result that Prof. Michelson was invited to continue the experiments at the Bureau of Weights and Measures, at Sèvres, France, where the standard meter, which is kept in an underground vault and inspected only at long intervals, was used for that important work, which occupied nearly a year. The final result of the experiments shows that there are 1,553,164.5 wave lengths of red cadmium light in the French standard meter, at 15 degrees Centigrade. So great is the accuracy of these experiments, that they can be repeated within one part in two millions. Should the material standard of length be damaged or destroyed, the standard wave length of light will remain unaltered, as a basis from which an exact duplicate of the original standard can be made. These two marvelous instruments, the Rowland dividing engine and the Michelson interferometer, show the possibilities in the perfection of linear divisions and the standards of length."

The interesting feature about the development of the branch of engineering science included in Mr. Swasey's address lies in the fact that much of the marvellously accurate work which he describes has been done in the modern machine shop, and that it has been found that the application of machine-shop methods to such work has greatly facilitated the improvement in the methods as well as in the resulting product. Conversely, the execution of such work in the machine shop tends to raise the standard of accuracy in all departments of work to the benefit of machine practice at large.

METALLURGICAL SLAGS.

THE FORMATION OF SLAGS IN METALLURGICAL OPERATIONS, THEIR CONSTITUTION AND INDUSTRIAL APPLICATIONS.

W. Mathesius—Revue Générale des Sciences.

IN nearly every metallurgical operation in which metals are reduced by exposure to temperatures above the melting point scoria and slag are formed, and the part which these play in the operations is one worthy of careful study. In a recent issue of the *Revue Générale des Sciences* there appears a general study of metallurgical slags, by Professor Mathesius, presenting in a condensed manner the general process of the formation of slags in the processes of metallurgy, together with some account of the efforts which have been made to utilize these products of the furnace.

There are two conditions under which slags are formed in the furnace: first, when the products of the reaction accompanying the metal, or formed at its expense, are not gaseous; and, second, when the minerals used contain in themselves constituents which become fused in the course of the operations. As examples of the first class may be cited the slags appearing in the operations of puddling, the Bessemer process, the open-hearth process, and the basic processes. In this class also belong the slags formed in the preparation of metals by reducing substances of which the oxides or sulphides are not gaseous, such as iron, silicon, and aluminum. Examples of this are seen in the metallurgy of lead, resulting in the displacement of the lead from its sulphides by iron; or, again, in the aluminothermic processes of Goldschmidt, in which the various metals are replaced, usually from their oxides, by aluminum, with the formation of alumina as a slag. The slags of the second class include those produced by the direct fusion of the flux in the production of metals in the high furnace, as in the smelting of iron, copper, lead, etc.

Slags have important functions in metallurgical operations, acting both in the collection of the reduced metal and also aiding in the production of the desired chemical reactions. Thus, when a metal is produced in a high furnace, the reduction of the oxides and the fusion of the mass take place above the zone at which the air is delivered through the tuyeres. The fused metal descends in small masses to the hearth of the furnace, but in so doing the isolated drops must pass through a region characterized both by a very high temperature and an oxidizing atmosphere. Each drop becomes coated with a film of oxide, which, if not

removed, would mingle with the metal on the hearth, to the deterioration of its quality. The drops of metal, however, do not fall directly into the bath on the hearth, but are received by the layer of fused slag, which, because of its lower specific gravity, floats above the liquid metal. Each drop of metal is thus cleansed of its film of oxide in passing through the layer of slag, the oxide thus removed being reduced anew by the carbon floating on the slag bath or partially dissolved in it.

Another function of the slag in a furnace is that of a regulator of temperature. It is the fusing point of the slag which determines the temperature maintained in a high furnace; thus the temperature of the melting of the slag determines whether lead is separated alone or in connection with iron; and, in like manner, the temperature in the blast furnace determines the production of gray or white iron.

The slag may serve as an intermediary in the reactions in the furnace, acting as a solvent for the reagents. An example of this is seen in the basic Bessemer process, in which the dephosphorization does not become active until a sufficient quantity of slag has been formed.

Slags may consist of sulphides, spinels (aluminates, ferrates, etc.), silicates, and phosphates. The manner in which these elements are combined is discussed at some length by Professor Mathesius, with especial attention to the series of silicates and of phosphates, from the point of view of the chemist, for which the reader must be referred to the original paper. As of especial interest to the engineer, the discussion of the methods of utilizing slags as by-products is of importance, especially in view of the necessity for disposing of the constantly accumulating mass of such material in the vicinity of all metallurgical works.

Slags formed of metallic oxides and sulphides, with the exception of those resulting from the processes of aluminothermy, are resubmitted to reducing operations, and need no further mention. The alumina produced in the process of aluminothermy is analogous to natural corundum, but exceeds it in purity and hardness, and finds a ready application as a polishing substance and as a material for the preparation of ceramic products possessing a great resistance to the action of acids united with a high thermal conductivity.

Numerous attempts have been made to utilize the silicate slags produced in such great quantity by the blast furnaces of various countries; the earlier attempts, as long ago as 1859, being to produce bricks or blocks of artificial stone for building purposes. By mixing pulverized blast-furnace slag with slaked lime, and exposing the moulded forms to the action of the air, it was found possible to make substantial blocks, but the cost of the grinding, and large proportion of lime required, rendered the operation unsuccesful commercially. It was not until the successful efforts of Lür mann, in 1870, to granulate the slag by delivering it into water as it flowed from the furnace, that the possibility of utilizing the material was made evident. Experience showed that the granulated slag possessed distinct hydraulic properties, similar to the natural puzzolana of Italy, and that by mixing it with about one-third part of slaked lime a cement was produced which could be made very useful for many purposes. Another use for the granulated slag appeared when it was found that it could be added, in a finely ground condition, to ordinary Portland cement, in quantities up to about 30 per cent. to the distinct improvement of the whole. Experience with these products showed that all slags were not suitable for the production of cement, and the trade disputes and contests which followed can readily be accounted for under such conditions. More recently the true method of making a high-grade cement from slag has been discovered, this being to mix the granulated slag with unburned limestone, and to vitrify the mixture in a kiln, the resulting clinker being ground to a fine powder, exactly as in the course of the regular manufacture of Portland cement. The product differs in no way from Portland cement, either in constitution or properties, and thus a standard material of construction is now being made in large quantities from what was formerly a useless and inconvenient by-product.

Professor Mathesius calls attention to a new method of producing a slag cement, developed by himself, and based upon the property of certain silicates of lime to swell and crumble in the presence of moisture. By taking certain basic slags and exposing

them, after granulation, to the action of high-pressure steam, they are found to swell and become decomposed into an exceedingly fine amorphous powder, which needs only to be mixed with water to form an effective cement. This process furnishes a cement much finer than has yet been produced by grinding, and at a lower cost, and it should find numerous useful applications.

The phosphate slags, resulting from the basic process of making steel, have been extensively used for purposes of fertilization. As they contain from 16 to [illegible] cent. of phosphoric acid, it was early attempted to prepare them as fertilizers by chemical treatment, but it was soon discovered that it was only necessary to expose the ground slag to the action of the atmosphere and weather for it to be converted into a satisfactory fertilizer.

The ground slag, when examined under the microscope, is seen to consist of isolated mineral particles, and it must be subjected to the process of disintegration before its phosphoric acid can be assimilated by plants. It is therefore useless, and even injurious, to use the basic slag upon growing plants, and the material should be placed upon the ground far enough in advance for the disintegration to be effected before the plants have arrived at such a stage of development as to be capable of absorbing the phosphoric acid.

Professor Mathesius has found that when the basic slag is subjected to the action of high-pressure steam it becomes disintegrated and pulverulent, much in the same manner as the siliceous slags, and that after this treatment the contained phosphoric acid is readily dissolved in the soil and assimilated by growing plants, so that this process may be found of value in connection with the use of slags as fertilizers as well as in the manufacture of cement without the necessity for grinding.

The whole development of this subject of slag utilization is an excellent example of the manner in which processes of manufacturing technology are overlapping, so that, instead of a process consisting of a main productive operation, accompanied by so-called by-products of doubtful value, we have, in many cases a series of parallel processes, each of much importance in itself, and all combining to utilize nearly every reaction involved.

STEAM TURBINES AND RECIPROCATING ENGINES.

THE BEST ECONOMY OF THE PISTON STEAM ENGINE AT THE ADVENT OF THE STEAM TURBINE.

J. E. Denton—International Congress of Arts and Sciences.

IN view of the general interest at present apparent in the steam turbine it is most desirable that the true relative position of the reciprocating engine and the turbine be critically established, and for this reason the paper presented by Professor J. E. Denton before the International Congress of Arts and Sciences at St. Louis is especially valuable at this time.

Professor Denton reviews the original dictum of Watt, that steam economy depended solely upon the expansion ratio, and showed how the defect in this, namely, the loss from cylinder condensation, did not appear in the Cornish pumping engine because the working end of the cylinder was never exposed to the temperature of the condenser. The experiments of Isherwood upon the engines of the Michigan, and their analysis by Rankine showed the real cause of the limitation, and led to the development of the compound and multiple-expansion engine, permitting an extension of the expansion ratio to be made to advantage. Taken together with the structural improvements in marine boilers, rendering higher steam pressures available, the development of the recprocating marine engine can be traced until, with boiler pressures of 210 pounds per square inch, and about 16 expansions in four cylinders, a water consumption of 13.6 pounds per horse-power-hour is recorded. This means, taking into acount the consumption of auxiliaries, etc., a fuel consumption of about 1.3 pounds of coal per hour for each indicated horse power.

"Without an increase in boiler pressure above 210 pounds further increase in economy can only be obtained with higher

ratios of expansion and this is prohibited because the consequent reduction of mean effective pressure would increase the weight of the engine per horse-power beyond commercially acceptable limits.

"With higher boiler pressure greater economy can be obtained from the engine by increasing the expansion up to probably a ratio of 30, but to accomplish this without increase of weight of engine per horse-power would require a working pressure of steam of 300 lbs. per square inch. This must be obtained from water-tube boilers, as the Scotch boiler is now at the limit of practicable construction and allowable weight when built for 210 lbs. steam pressure.

"Higher economy of engine is obtainable, with present pressures and ratios of expansion, by the use of superheated steam, but the application of the latter has not thus far shown a gain in coal economy in trans-Atlantic marine practice. This is doubtless ascribable to the use of imperfectly-designed superheaters; but the increase of cylinder oil which superheating requires makes its successful introduction at sea questionable, on account of the difficulty of protecting the boilers against over-fouling by accumulation of oily deposit.

"At the advent of the steam turbine in marine practice, therefore, the degree of economy with which it must compete, in marine engines on the largest scale, is that of a quadruple-expansion system expanding saturated steam with 210 pounds pressure, fifteen times, into a vacuum of 25.5 inches with an economy of 13.6 pounds of water per horse-power-hour of the main engine; which will operate, with its auxiliaries, from Scotch boilers on the Howden system, with a consumption of 1.3 pounds of the best semi-bitumenous coal per indicated horse power of the main engine.

"If the turbine could operate screw propellers efficiently with the same rotational speeds for a given horse-power that it uses in electric service, the record for economy already established by the turbine shows its ability to easily compete with these conditions of performance of the best marine engine. But such rotational speeds for the turbine are inconsistent with the degree of screw propeller efficiency available from piston engines.

"Therefore the possibilities as regards steam economy of the turbine in marine practice are as yet too unsettled to permit of their definite statement within the limits of this paper.

Passing to the stationary engine, Professor Denton shows how, by the introduction of compound and triple-expansion engines, the water consumption of 19 pounds per horse-power-hour attained in the simple stationary engine has been lowered to about 12.5 pounds, and how this has been equalled by compound engines of large cylinder ratio, about 7 to 1, and also by compound engines of lower cylinder ratios.

"These facts show that the minimum water consumption of the compound mill engine, and electric light engine of the present day, using saturated steam, is not dependent upon any particular cylinder ratio and clearance nor upon any system of jacketing, but that the essential condition is the use of a ratio of expansion of about 30, above which the cylinder-condensation loss is liable to prevail over the influence of the law of expansion. The conclusion appears warranted, therefore, that if this ratio of expansion is secured with any of the current cylinder and clearance ratios, and with any existing system of jackets and reheaters, or without them, a water consumption of 12.4 pounds per horse power is possible, and that a variation of four-tenths of a pound below or above this figure may occur by the accidental favorable or unfavorable jacket and cylinder-wall expenses which are beyond the exact control of the designer."

Comparing these piston-engine performances with those of the steam turbine, Professor Denton shows that it is necessary in the latter machine to use the brake horse power, since no indicator diagrams are possible, and by making reasonable allowances for the frictional resistances of the piston engine he gives, for the water consumption per brake horse-power-hour, 14.51 pounds for the turbine as against 14.56 and 14.64 pounds for American and Continental engines respectively.

"While the mill and electric practice has developed the compound engine, pumping engines in the United States have been de-

veloped in the triple-expansion fly-wheel type to a degree of economy superior to that afforded by any compound mill or electric engine, and, for saturated steam, superior to that of the pumping engines of any other country. This is because their slow speed permits of greater benefit from jackets and reheaters and of less losses from withdrawing and back pressure. These causes, together with the greater subdivision of the range of cylinder, have resulted in records made between 1894 and 1900 of 11.22, 11.26 and 11.05 pounds of saturated steam per indicated horse-power, with 175 pounds steam pressure and from 25 to 33 expansions, in the cases of the Leavitt, Snow and Allis pumping engines, respectively, the corresponding heat consumptions being by different dispositions of the jacket drainage, 204, 208 and 212 thermal units per indicated horse-power-minute; while the Allis pump, with 85 pounds steam pressure, has lowered the record to 10.33 pounds of saturated steam per indicated horse-power, with 196 heat units of consumption per horse-power-minute.

"The turbine can compete with these pumping engines only through the medium of a multiple-stage centrifugal pump, whose efficiency taken even at 80% will probably impose too great a loss of motive power on the turbine system for successful competition with this high class of piston pump, since the friction loss of the latter is only 5% of the indicated horse-power."

With regard to the questions of superheating and of the utilization of the waste heat in engines of the binary vapor form, such as the sulphur dioxide engine of Josse, Professor Denton shows that similar methods are applicable to the turbine as well as to the piston engine, and hence may be considered as eliminated from the comparison.

"The turbine, therefore, even at this early period of its history, is already a formidable competitor to the piston steam engine in its most economical degree; and that it is so is mainly due to the fact that with no more waste in its steam action from internal friction than is due to the cylinder-wall wastes of the piston steam engine which are absent in the turbine, it more completely realizes the expansive principle enunciated in the infancy of steam history as the fundamental factor of economy, by its sagacious founder, the immortal James Watt."

WATER-TUBE BOILER DESIGN.

A COMPARISON OF THE EFFECTIVENESS OF WATER-TUBE BOILERS FOR VARIOUS POSITIONS OF TUBES.

W. R. Cummins—North-East Coast Institution of Shipbuilders.

WATER-TUBE BOILERS may be broadly divided into two classes, according to the general position of the tubes. In one class the tubes run in a vertical, or nearly vertical position, while in the other the position is nearly horizontal. The respective merits of these two arrangements are discussed at length in a paper presented before the North-East Coast Institution of Shipbuilders by Mr. W. R. Cummins, and the general subject of the design of water-tube boilers is treated at length in the same connection.

Mr. Cummins naturally considers the boiler with especial reference to marine service, but the general points apply to stationary purposes as well. The conditions necessary for commercial success in a boiler are enumerated as those affecting the fuel economy, the weight and space economy, the cost or capital economy, and the economy of operation or maintenance. The relative importance of these various conditions depends somewhat upon the service, the matter of weight, for instance, being an important question for a marine boiler, and of secondary consideration for land service.

The conditions necessary for high fuel economy are stated to be perfect combustion and perfect efficiency of heating surface.

"Perfect combustion is an unmixed blessing and does not interfere with any of the other economical conditions. On the other hand, to secure perfect efficiency of the heating surface would mean an almost unlimited amount of it, which would seriously interfere with weight and cost economy.

"One of the chief sources of loss in burning fuel in a boiler is due to the excess air which has to be admitted to provide for complete combustion to CO_2 and H_2O. The whole of this excess air has to be heated up to the temperature of the rest of the gases and thus carries off a great deal of heat to the funnel. This source of loss is common to all boilers and may be largely reduced by skilled firing and proper proportioning of firebar spaces and air admission. It is very probable that with oil-fuel the excess of air over that actually required for perfect combustion is not so much as with coal-fuel; hence the furnace efficiency should be greater."

In considering steam boiler economy it must always be remembered that the furnace is distinctly a piece of chemical apparatus, and that its function is the production of heat by the combustion of fuel, while the boiler proper is a piece of physical apparatus, designed to absorb the heat produced in the furnace and convert it into mechanical energy in the steam.

Considering the furnace in itselt, it is generally admitted that the form and size of the combustion chamber is an important element. By the combustion chamber is meant the space immediately succeeding the grate, along the direction of the movement of the products before the actual heating surface of the boiler is reached. In order that the combustion should take place effectively it is necessary that the gases should be caused to mingle thoroughly with the air, and that sufficient time should be given for the chemical changes demanding a high temperature to be completed before the cooling surfaces of the boiler are reached. The rate of transfer of the heat from the gases to the water depends upon their difference in temperature, so that the efficiency of both the furnace and the boiler depend to a large degree upon the production and maintenance of a high temperature in the combustion chamber. In any case the time occupied by the passage of the gases through the boiler is never more than a few seconds, so that every facility for the completion of the combustion and the transfer of the heat must be given if even a fair degree of efficiency is to be secured.

Mr. Cummins points out that the various designs of boilers with vertical water-tubes give an excellent opportunity for the provision of a large combustion space having its greatest dimension in the line of the flow of the gases, while those forms in which the tubes are horizontal, or nearly so, have the lower rows of tubes just over the grate bars, where the green gases coming off the fuel must be cooled down below combination temperature. In some forms of boilers the combustion takes place in a sort of Dutch oven, placed in front of the boiler proper, this being a recognition of the desirability of providing for better facilities for combustion before the heating and cooling surfaces of the boiler are reached.

Coming to the elements in design which affect the efficiency of the boiler itself, Mr. Cummins shows that the maximum possible economy in the transfer of the heat depends upon heating-surface efficiency. Theoretically the greatest efficiency would be obtained when the temperature of the escaping gases in the chimney was just equal to the temperature of the water in the boiler, but such a condition is commercially impracticable. In actual practice the attention which can be given to heating-surface efficiency is limited by other requirements, and like all other engineering structures, a steam boiler is a compromise. When economy in weight is the controlling question the heating surfaces are necessarily restricted and the chimney temperatures are consequently high. In like manner economy in cost involves limitations to heating surface and corresponding diminution in efficiency. In every case, however, it is desirable to put the heating surface into the most efficient condition, and the elements by which the designer is able to influence the quality of heating surface are enumerated as: thickness of transmitting surfaces; circulation of the water; and circulation of the gases.

The thickness of the surface is not a matter of very great influence upon the transmission of heat, within the limits of thickness ordinarily used in steam boilers, the condition of the surfaces being more important, and freedom from soot on one side and scale on the other are of greater moment, so that facility for keeping both surfaces clean enter into the design.

So far as circulation of the water is concerned, the vertical tubes undoubtedly have the advantage, and none of the devices used in horizontal tubes, such as inner tubes or diaphragms, circulating nozzles, etc., need be employed when the tubes are placed nearly in the vertical position. Boilers using vertical tubes are also free, in most cases, from the use of narrow and tortuous headers, so that a freer entrance and discharge may be provided.

Considering the circulation of the gases, it has already been noted that the entire duration of contact is very short, but it should be prolonged as much as possible, since the time element is an influential one. By the introduction of suitable baffle plates the gases may be prevented from passing directly to the chimney, and directed against portions of the heating surface which would otherwise receive less heat. In this respect there is not much difference between vertical and horizontal tubes, examples of both kinds being cited in which the baffles are well arranged to prolong the duration of contact. An important matter in connection with baffle systems is their maintenance, since the presence of leaks will materially diminish their effectiveness, and in this respect the vertical tubes have an advantage.

Mr. Cummins considers that it is best to have the path of the gases as nearly at right angles to the tubes as possible, and this idea seems to be generally prevalent. It has been pointed out, however, that the direction of contact of the gases with the tubes is not a matter of great importance, since the real cause of the transfer of the heat is the difference of temperature and not the "impinging" of the gases against the metal. It is well known that vertical fire-tube boilers are fully as efficient as the horizontal variety, and the same should be true in water-tube boilers regardless of the direction of the transfer of the heat.

Summing up, Mr. Cummins says, that so far as fuel economy is concerned, a large and high combustion chamber is an absolute necessity; and that vertical tubes, as small in diameter as practicable, are preferable in all respects to horizontal ones. It is equally important that the gases, on leaving the combustion chamber to enter among the tubes, are not rushed through too quickly, but are allowed sufficient time to give up their heat. It is also desirable that the gases be split up and divided into as many narrow streams as possible.

Mr. Cummins considers at length the conditions involved in the use of water-tube boilers on shipboard, especially in connection with economy in weight, and he shows the advantages of the vertical tubes in this respect also, his views in this direction agreeing closely with those of the Admiralty boiler committee.

VIBRATORY SPEED INDICATORS

THE ACCURATE DETERMINATION OF HIGH ROTATIVE SPEEDS BY THE UTILIZATION OF THE PRINCIPLE OF RESONANCE.

Friedrich Lux—Verein Deutscher Ingenieure.

HIGH rotative speeds have always been difficult of direct measurement, except by the use of expensive and complicated apparatus, and for a long time there has been a demand for a simple and reliable speed indicator. The various forms of revolution counters acting by pressure contact at the end of a revolving shaft or spindle become unreliable as well as inconvenient at high speeds, besides involving the noting of the time as well as the reading of the index. With the increasing use of machinery operating at high speeds, such as dynamos, motors, steam turbines, centrifugal pumps, etc., it has become more and more desirable that a good speed indicator should be available.

In order to meet this demand, and as a direct outcome of his own researches upon the vibration of screw-propeller shafts, Herr Hermann Frahm, a well-known marine engineer of Hamburg, has devised an apparatus which utilizes the principle of resonance to indicate the speeds of machines with which it may be connected, and from an article by Friedrich Lux, in a recent issue of the *Zeitschrift des Vereines Deutscher Ingenieure*, we make the following abstract, describing its construction and operation.

The phenomenon of resonance is the property possessed by elastic bodies of responding to rhythmical impulses corresponding to their own period of vibration. A familiar example is found in the manner in which the strings of a violin or other stringed instrument can be felt to vibrate when their corresponding notes are sounded from some other source, and nearly every one is familiar with the experiment of making a glass lamp-shade ring by the singing of tne note which it emits when struck. In fact it is upon this principle that the ear is supposed to possess the capacity of perceiving various tones, certain fibres responding to external vibrations corresponding to their own periods.

Herr Frahm has utilized this principle by the production of a very simple apparatus, this consisting merely of a set of vibrating reeds or tongues, made from pieces of watch spring, and tuned to different rates of vibration by being made of various lengths, and loaded with different weights. Each reed consists of a piece of watch spring, a set of such reeds being clamped between a pair of jaws so as to form a sort of comb, not unlike the steel tongues used in an ordinary musical box. The bar to which the reeds are fastened is also supported by a sort of spring suspension at one or both ends, the reeds standing vertically in a row. Each reed has its upper end bent sharply at right angles, and in the angle thus formed a drop of solder is placed, the size and weight of this piece of metal, together with the length and density of the reed, determining its time of vibration. It is thus possible to prepare a set of reeds having successive rates of vibration between any given numbers, and by covering the ends of the reeds with white enamel their movements are made clearly visible.

If such an apparatus is placed upon the base or frame of any machine in operation the vibrations, although imperceptible in themselves, will immediately affect the reed having the same rate or frequency, and as this reed can be readily seen, its number gives the speed of the vibrations. In many instances this is sufficient, but when the speed is to be read at a distance, or it is important to investigate any particular portion of a machine, the vibrations may be directly communicated to the comb. Thus a slight projection upon a rapidly rotating shaft may be used to cause a lever to make an oscillation for every revolution, and this, when communicated to the comb, will cause a response to be made especially by the reed having the same frequency. In this way revolutions far exceeding in number any possibility of ordinary counting or recording may be indicated very closely, this method having been successfully applied to steam turbines, Pelton water wheels, centrifugal cream separators, etc.

Another very useful method of setting the apparatus into vibration is to employ an electric current, a soft iron armature being attached to the bridge or base of the comb, and an electro-magnet, through the coils of which a current passes, set into vibration by a soft-iron toothed wheel, furnishing the impulses. In the case of alternating current machinery it is only necessary to cause the alternating current to pass through the coils of the electro-magnet and the number of vibrations thus caused will immediately be selected by the reed having the same period, and its increased vibrations will enable it to be perceived without difficulty. The advantage of the electrical method especially is that it renders it possible to place the indicator at any distance from the machine under observation, speeds having been successfully indicated by this method at points as far as 10 kilometres distant from the source.

One of the most important functions of such a device is its capacity for separating or analyzing a number of combined vibrations. If a number of rates or frequencies exist in the impelling source the reeds corresponding to the several simple frequencies will all be set in motion, and any great difference in their amplitude may serve to enable the predominating speeds to be selected for examination or study.

It is evident that such a device as is above described will find continually increasing applications, especially in view of the continual effort now apparent to do away as far as possible with reciprocating and alternating motions and use rotating parts wherever possible. Although every effort is made to avoid vibration in such machines as turbines, centrifugal pumps, blowers, etc., it is rarely found that entire freedom from

periodic effects exist, and hence speeds can nearly always be determined by the use of analyzing reeds in the form devised by Herr Frahm. Of course it is not necessary to provide a great number of reeds upon a single comb, as the range of speeds under consideration is always fairly well known in any given case, and combs containing but a few reeds may be arranged for special purposes. The entire apparatus is but another example of the manner in which the methods formerly confined to the physical laboratory are being employed in daily and practical shop service, to the improvement both of the quality and quantity of work-shop information.

MODERN WAR-SHIP DESIGN.

A PLEA FOR THE ADOPTION OF SIMPLER METHODS OF DESIGN AND CONSTRUCTION OF SHIPS OF WAR.

G. W. Dickie—Society of Naval Architects and Marine Engineers.

AMONG the important papers presented at the recent meeting of the Society of Naval Architects and Marine Engineers we note one by Mr. George W. Dickie, supplementing a paper which he contributed five years ago, and treating of possible improvements in war-ship design. At the time of the presentation of the previous paper, in 1899, Mr. Dickie gave two fundamental reasons for the complicated conditions existing on war vessels, and these, he affirms, exist to-day to a still greater degree. These are:

First: Uncontrolled growth of new devices for doing the many things for which mechanism is required on these vessels, without the new devices being considered reliable enough to supersede the old. Hence duplication, and, in many cases, triplication of apparatus for doing one thing for which one good device alone should be used.

Second: The system of divided control over the work renders it impossible to have a homogeneous design to begin with that would enable the ship and all that is required of her to be treated as one machine, and provision made at the start for every function being considered with relation to every other function.

"Since 1899 additional causes of complication have been brought into play. Special experts in certain lines of work have been given charge of the work in which they are expert, thus bringing about a struggle for room to place all the devices the experts think to be necessary to make their specialties complete. To make this possible, specifications have been prepared and cleverly worded to cover the unknown requirements of the future, which, when finally worked out, produced two results—a tangled mass of complications on the ship and a financial complication to the contractor. This further increase of complication has developed so rapidly during the past three years that shipbuilders have suffered very great losses in consequence. Ships now building, or in the last stages of completion, and which were supposed to be duplicates of those already built, the specifications and original plans having been identical, have been made much more expensive, more complicated, and, I fear, less efficient, by this process, most of which has been brought about at the shipbuilder's expense, through elastic specifications and non-elastic Boards on Changes."

In general Mr. Dickie presents in his paper an affirmation, and to some extent an elaboration of the idea suggested in his paper of five years ago, namely, the provision of a central passage, or sort of subway, so to speak, running throughout the entire length of the vessel, and containing in accessible arrangement all the appliances for managing and controlling the vessel. This idea has been expanded and developed, and in the present paper it is considered in connection with the design of an armored cruiser, although it is manifestly adapted for any other type of ship.

This passage, according to Mr. Dickie's plans, would be arranged as one water-tight compartment, without any subdivision between the bulkhead and the forward end, about 50 feet from the ram, and the automatic door just forward of the steering-gear compartment. Such a compartment, arranged according to Mr. Dickie's plans appears to be placed so that no damage, short

of the total destruction of the vessel, could impair its integrity.

The first, and one of the most important uses of the central passage is for the simplification of the drainage system of the vessel. Beneath the central passage, in a space formed between two vertical keel plates, there would be a central gutter or main drain, and into this, through openings provided with valves, each compartment would be drained.

"The main drainage well is in itself a water-tight compartment, all openings into it being controlled from the central passage. Its size is 24 inches by 30 inches, being large enough to admit a man for inspection and painting. We have thus provided, as far as horizontal drainage is concerned, a complete system without adding anything to the general structure of the vessel, and it is a real drainage system into which every compartment above the inner bottom naturally drains, requiring only some simple means of lifting water that drains into the space between the vertical keels, and discharging it overboard.

"I would propose to abolish the whole present system of horizontal piping, and all manifolds and emergency connections to circulating pumps, with all their numerous connections and valves. I would have no such unnatural combination as a bilge and fire pump or a feed and bilge pump—the two functions are entirely opposed to each other. A good bilge or drainage pump is of no use as a fire or feed pump, and a good fire or feed pump is the worst possible form of pump for drainage purposes, for the reason that a drainage pump should be able to take either wind or water or any combination of the two, and that is what the type of steam pump called a fire and bilge pump will not do."

Passing to the question of ventilation, Mr. Dickie proposes to run an air trunk to connect with the central passage, the air being drawn in by electric fans, and delivered directly to the passage, which thus becomes the main air duct for the whole ventilation of the ship.

"All compartments requiring artificial ventilation, except the boiler compartments, will receive the air necessary for that purpose from the central passage. From the roof or sides of the passage, air ducts will extend to the determined point of delivery. This includes the main engine rooms and the dynamo rooms. All openings into the ducts will be closed by water-tight gates operated in the passage. These gates or valves will be opened or closed by the man in charge of ventilation in the passage, on order from the compartment or room to be ventilated. In living spaces the air would be delivered not far from the floor or deck of the compartment being ventilated, through a special type of louvre, arranged to stand close to the bulkhead and with slats to direct the air to any part of the room or compartment, as required. For all living spaces, the outlets from the central passage would be small, so that each room or compartment would have its own independent connection with the air supply. This is necessary in connection with another part of this arrangement, whereby the steam heater arrangement or radiator system is combined with the ventilation. At each outlet taking air to living quarters and berthing spaces a special radiator is fitted. This is combined with the shut-off valve, being a double coil, circular in form, made without joint, and so arranged that the ai on its way through the outlet must pass over the surface of the pipe forming the coil and thus becomes heated. This forcing the cold air over the steam-heated surface of the radiator would be very effective and enable the surface, in proportion to the space to be heated, to be very much reduced from that of the ordinary radiator. The amount of steam applied to the radiator would be regulated by the man in the central passage in charge of the heating system, as ordered from the rooms or spaces requiring hot air. Each room or space can thus be kept at the temperature required by the occupants, the steam pipes to and the drain pipes from the heaters would all be installed in the central passage and in charge of the man assigned to the duty of taking care of the heating arrangements. This removes a lot of steam pipes and fittings from the living spaces in the ship, where they are a continual source of trouble, and usually, to a large extent, very difficult to get at for repairs, and placing them where they will be always in sight, and in unobstructed lines where repairs and renewals can be made with the least trouble and expense."

The central passage naturally aids greatly in simplifying interior communication through the ship. By using telephones for all transmission of orders, and by placing a central telephone station in the passage the whole question of the transmission of instructions would be carried on as it now is in any well-regulated building ashore.

The entire system of fire mains would naturally be installed in the central passage, where immediate access could be had to any connection, the fire pumps being placed in a pump room, situated between the main engine rooms and the after fire rooms. In like manner all the piping involved in the pumping of the ship, including the connections for the bath rooms, water closets, etc., find a place in the central passage.

"Circulating water for the distillers would be taken from the flushing main and discharged overboard or returned to the main at a less pressure, if desired. Magazines above the water-line would also be flooded from the flushing main. Magazines below the water-line would be flooded by special arrangements as they are now. By this arrangement all plumbing and sanitary work would be arranged just as it is for a city water-works system, except that the water would be salt instead of fresh. In the branches leading up to such bathrooms as should have hot water, arrangements would be provided in the central passage for heating the water as required from the heater system, a coil being used for that purpose so as to avoid any loss of fresh water from the boilers. The party ordering the water from the central passage would give the temperature required. Hot water would be arranged for officers' baths and sick bay only. The engine room water service would also be taken from the flushing main by a branch direct from the pump discharge before it enters the central passage."

The general use of electric power on shipboard renders the central-passage plan especially well adapted tor the running of the necessary wiring. By having two independent dynamo rooms, situated on each side of the central passage, the switchboards may be arranged directly against the walls of the passage, and the wires run directly into conduits running along the sides of the passage, all branches being carried through water-tight stuffing boxes.

Mr. Dickie also treats in his paper of improved methods of coaling and of handling boats, and brings to all the details of warship design the fruits of his ripe experience, untrammelled by any of the hampering prejudices so apt to exist in the limitations of the official mind, and the result is a refreshing example of common sense applied to the use of materials, which, as Nasmyth has said, constitutes the highest qualification of the engineer.

IMPACT TESTS ON STEEL.

SUGGESTIONS FOR MORE RATIONAL METHODS OF TESTING STEELS IN CONNECTION WITH RESISTANCE TO SHOCK.

A. E. Seaton and A. Jude—Institution of Mechanical Engineers.

MATERIALS of construction may be tested in various ways, and the choice of the method of testing should depend largely upon the use which is to be made of the information thus acquired. In the methods usually employed the object is to determine the general properties of the material, and this being the case, there is no reason to vary the standard methods of testing by tension upon machines of approved type.

More recently there has arisen a feeling that materials of construction, and especially the standard commercial varieties of steel, should be tested under conditions approximating more closely those in connection with which failure may be expected. When a machine or other structure is carefully proportioned with respect to the working stresses and the normal resistances of the materials there is little danger of a breakdown in the ordinary course of operation. It is when some violent and unexpected shock occurs that the material gives way, and such conditions are far more difficult to meet than those met in the ordinary course of operations.

In a paper recently presented before the Institution of Mechanical Engineers by Messrs. A. E. Seaton and A. Jude, this

question is taken up in a very practical manner, the paper attracting much interest among engineers and manufacturers generally. As the authors themselves state:

"The objects of the paper are to show some of the characteristics and peculiarities of the wrought steel as supplied by steel manufacturers for commercial purposes; to assist in the development of a more rational method of testing the suitability of such steels for each particular purpose of the engineer; and to point out a few of the peculiarities that are observed in the fracture of test specimens and actual pieces of machinery. It is in fact the outcome of the constant endeavour of engineers to avoid the use of material which might be dangerous in the construction of machinery liable to severe alternating stresses, and more especially to attempt to find the very best steel for those parts liable to shock, owing to the inability to make those parts larger in the very fast moving engines so much in demand to-day."

The various methods of testing steel are enumerated as including tension, compression, cross-bending, hammering out to a point or edge, fatigue by gradual reversal of stress, either in one plane or over the entire section, impact on notched and unnotched bars, chemical analysis, and micro-analysis.

The choice of the method of testing should depend to some degree upon the use to be made of the material under consideration. For structural work subjected to steady loads only, or to recurrent loads of only one kind, the tension test is a good and sufficient one. When, however, the structures are to be subjected to rapidly repeated loads of one kind, all more or less suddenly applied, as with bolts, studs, rails, etc., or to alternating loads, as in the fixed and moving parts of machinery, or as in many parts of a ship, something more is needed. The manner in which members subjected to such actions give way is sufficient evidence that the ordinary tension test does not give information which can be depended upon by the designer in determining dimensions and proportions.

An examination of the conditions of operation of a high-speed reciprocating engine, for example, shows that more than 87 per cent. of the whole machine is subjected to more or less shock, while pure tension forms an insignficant percentage of the whole stress. Similar conditions exist in the case of printing and textile machinery, and in nearly every kind of machine tool. Experiments upon the failure of bolts and studs show that fractures take place after a number of vibrations representing a short life in the case of high speed machines.

Under such conditions it appears that it is only by the careful use of the shock test that useful information can be obtained about materials which are to be used in this manner, and it is the impact test which the authors recommend for practical use. In making such tests the use of the notched bar is recommended for the test specimen, the practice of the Continental experimenters being followed to this extent. The advantages of the notched bar are, that it gives a gauge of the preponderant stress, and that it gives assurance of good ductility. This latter point is important because it has been shown that there may be obtained excellent results from tension and elongation tests with steels which are quite incapable of resisting shocks, while the impact test settles the question of resistance to shock and of ductility at the same time. Another important reason for using the notched test bar is because it represents more nearly than any other the existing state of affairs in actual work. Probably 99 per cent. of all forgings are notched in some way or other, not necessarily with a V nick, while sharp edges, internal and external, cannot always be avoided in machine design, or even deep scratches in actual construction.

"Opinions differ as to the best means of making the impact test, but on the whole the consensus of opinion appears to be that it should be made with a machine that breaks at one blow, and at the same time measures the energy expended in breaking the specimen. Mr. Frémont thinks that breaking by a series of blows gives results that are similar to those from a static bending test, that is, they are more a gauge of ductility and tensile strength than to resistance to shock. The authors are not with him in this opinion, provided that the blows are not heavy enough to produce material bending; it is possible that he means in this sense, much in the same way as Heyn

adopted in a series of experiments on the 'overheating of mild steel.' Here he had a nicked bar with one end stuck in a vice. A blow was given by a hammer, bending it over to a right angle. A reversed blow knocked it back again, and so on until fracture occurred. This is not the method the authors have adopted, for with the weight and size of specimen used the bending is very small indeed even for the softest steels.

"From the very many bars that have been tested by them they have found the number of blows to produce fracture is a fair gauge of the toughness or anti-brittleness. But there is no relation whatever between this result and the tensile results except what has previously been mentioned, namely, that if the impact result is good the elongation is sure to be good too, but, on the other hand, a steel showing high tensile strength and good elongation may be useless to resist shock."

The second portion of the paper of Messrs. Seaton and Jude discusses the nature and peculiarities of the fracture of mild steel by shock, using the methods of metallography for illustration. It is impracticable to review this at length without reference to the numerous excellent micro-photographs, and the original paper must be consulted, but the thoroughness with which the nature and constitution of the fractures have been studied must be commended.

An appendix to the paper gives an abstract of the results of tests.

ELECTRIC LOCOMOTIVE TRACTION.

PUBLIC TESTS OF THE NEW ELECTRIC LOCOMOTIVE FOR SERVICE ON THE NEW YORK CENTRAL RAILROAD.

Electrical World and Engineer.

A FEW weeks ago there was made on the tracks of the New York Central & Hudson River Railroad some very interesting public trials of an electric locomotive, of the type now under construction for the service of the trains running out of New York City. Although the locomotives of which the machine tested was an example, are not intended to replace steam traction entirely, and will be used simply to provide an acceptable means of drawing the trains through the tunnel and beyond the suburbs by insuring freedom from the nuisance and dangers of smoke and steam, they will undoubtedly prove a powerful argument in the task of showing that electricity has capabilities hitherto undemonstrated.

A brief statement of the facts in connection with the service of these machines will show the importance of the matter.

"The New York Central & Hudson River Railroad Company is now electrically equipping its terminal network for a distance of 34 miles on the main line from the Grand Central Station to Croton, near Peekskill, and for 24 miles on the Harlem Division as far as White Plains. It is the intention to handle all the traffic within this district or zone electrically, and the locomotive just given trial is one of thirty to fifty which will be used in the haulage of the through passenger trains, the heaviest of which reach 875 tons in weight and are to be hauled at a maximum speed of 60 to 65 mechanical horse power. By the use of the Sprague General-Electric multiple-unit system of control, two or more locomotives can and will be coupled together and operated from the leading cab as a single unit. The motive power may, therefore, be easily adapted to weight of train with no complication in operation and with uniform make-up of train crew. A single electric locomotive will be able to maintain the schedule with a 450-ton train, two locomotives being coupled together for heavier trains.

"This change of motive power is confidently expected to show marked economy in the electrified part of the railroad as a whole and a sharp increase in the suburban traffic, on account of the frequency of service, the greater acceleration, the purification of the Park Avenue tunnel, as required by law, and the general increase in the comfort, convenience and cleanliness of the methods adopted. As already noted, one step in the change of motive power has been the location of two large central turbo-generator power plants, one on each flank of the district served, namely, at Yonkers

on the Hudson and Port Morris on Long Island Sound. Each of these plants, already designed and in embryo construction, is to have an ultimate capacity of 30,000 kw., with an auxiliary system of substations and storage batteries and an interconnection that will enable either plant to do the whole duty and carry the entire load of a train service far beyond that which depends upon the present steam schedule."

A general description of the locomotive is given in the article above referred to, and but a brief account will be necessary here. One of the most important features noted is the fact that the electric motors, of which there are four, are directly attached to as many axles, there being no gearing. Each motor is of 550 horse power, thus giving 2,200 horse power for the machine, and in the course of the trials there has been developed 2,780 horse power at the motors. This output is secured without in any way exceeding the safe commutation limit of the motors, and with a coefficient of traction of only 22.5 per cent. of the weight upon the drivers, thus placing this electric locomotive in advance of any steam locomotive yet built.

"Throughout both the starting and running tests the electric locomotive shows its remarkable smoothness and steadiness in running, a distinct contrast in this respect to the steam locomotive, especially should the latter be forced to perform the work here shown to be accomplished by the electric locomotive. The elimination of gear and bearing losses permits of a very high efficiency of the locomotive. Reference to the motor characteristics shows a maximum efficiency of approximately 93 per cent., this value being fully 4 per cent. better than possible with motors of the geared type. This gain is especially noticeable at the high speeds, the efficiency curve remaining above 90 per cent. even at the free running speed of the locomotive alone, in contrast to the 85 per cent. or less which would be a good showing for a locomotive provided with geared motors. The simple construction and high efficiency made possible with this design of gearless motor, together with the minimum cost of repairs attending such a construction, makes the direct-current, gearless motor type a distinct forward step in electric locomotive construction.

"Compared with existing steam practice, it is interesting to note that the heaviest 'Atlantic' type locomotive of the New York Central Company weighs approximately 150 tons, including the tender, on which but 47 tons are on two pairs of drivers. It will, therefore, be seen that for every pound of effective drawbar pull the steam locomotive has a weight of over 12 pounds, as compared with but 6 pounds with the electric locomotive. Therefore, in a single electric unit, over 25 per cent. greater weight is available for traction than with the largest steam passenger locomotive now in use, with 37 per cent. less dead weight and with 28 per cent. less weight on each axle. Moreover, the electric locomotive will, of course, have an entire absence of counterbalancing of driving wheels and twist from reciprocal motion, both of which in the steam locomotives are so destructive to track and roadbed."

The various runs which were made before a critical party of engineers and scientific men showed the capacity of the machine to be fully equal to any of the demands which may be made upon it. An eight-car train, weighing 431 tons, was hauled at a speed of 63 miles per hour, while a four-car train, of 265 tons weight, reached a speed of 72 miles per hour.

"A question that arises in connection with the application of electricity to the heavy service of the New York Central is that of heating. It is expected that in the majority of instances sufficient heat will be retained in the trains delivered to the electric locomotive at the end of the steam run to carry the cars to the terminal without any additional heat from the locomotive. To meet an emergency or contingency of this kind, however, it is probable that a flash boiler of the automobile type will be used on the electric locomotive, occupying but a small space in the operator's central cab, where at present a good deal of room is available. It will be understood that for the ordinary suburban service of the company within the electrical area, the usual electric heating equipment now familiar on street cars will be installed. But, of course, at this early stage, all kinds of passenger cars will be coming in as usual over the New York Central from foreign systems where electric traction has not yet been adopted, and for

these at least some such provision as that noted above is in contemplation."

With such experiences as have been recorded in the trials by the New York Central Railroad, together with the success of the Orleans Railway in Paris, and the plans of the Pennsylvania Railroad for New York, it is evident that the era of the use of heavy steam locomotives for the hauling of trains into terminals in the densely populated portions of great cities is passing, and that before very long the general practice will relegate the steam locomotive to the hauling of the trains through the open country, leaving the terminal work to be done entirely by means of electric traction.

CHEMISTRY IN THE FOUNDRY.

PRACTICAL APPLICATIONS OF METALLURGICAL CHEMISTRY IN THE SUCCESSFUL CONDUCT OF FOUNDRY OPERATIONS.

Dr. Richard Moldenke—New England Foundrymen's Association.

IT has long since been demonstrated that the services of a competent chemist and laboratory are necessary for the profitable conduct of the business of manufacturing iron from the ore, but the practical value of the chemist to the iron foundry is a matter of more recent demonstration. In a recent address delivered before the New England Foundrymen's Association, Dr. Richard Moldenke gives some excellent reasons why the services of a chemist should be considered, and how they may be made of commercial and practical value.

Dr. Moldenke makes a warning against the mistake of assuming that the first thing to be done is the establishment of a laboratory, to analyze and dissect everything that is used or made. Such a procedure involves unnecessary expense, antagonizes faithful workmen, and often fails of its purpose. A full working laboratory may be found advisable and profitable in connection with a large establishment, after its proper use has been found out, but the better plan at first is to proceed slowly, and use the cheapest means to the end until the progress made warrants the addition of a complete laboratory department.

The chemistry of iron can be made to pay almost immediately in the matter of the purchase of pig iron, and to-day more than three-fourths of the iron used is bought on chemical specification.

"Here the foundrymen, once he knows what he needs for his work, can specify the analysis required, and is certain of getting a more uniform material than ever he could when iron was judged by its fracture. The variation allowed the furnace before the shipment becomes subject to penalties, or even rejection, is such that a careful spreading of each carload on the last one of the same approximate composition, and drawing from the end of the pile, will give such uniform charges that, with a good melter at the cupola, no anxiety need be had about the metal tapped out daily.

"This may be said to be the first benefit of the chemistry of iron to the founder, and he needs no laboratory for this on his own place, but simply a consultation with some one who knows what he requires in the first place, next careful sampling by a bright foreman or assistant and then a commercial analysis."

The next place where chemistry may be applied is in the purchase of coke, but here the matter has not made the same degree of progress. It is well understood that the presence of too much sulphur is detrimental to a foundry coke, and it is beginning to be realized that appearance and name are not in themselves sufficient guides in the selection of coke.

"As it is, you can specify and buy your coke with the sulphur down to 1 per cent., provided the makers will give it to you, and with a good coke or anthracite and uniform iron your charge on the cupola platform is as good as can be made, being the practical application of science directly where it pays well, and all this with a cost of but a few cents a ton added to the iron tapped at the cupola spout. As a simple matter of insurance this added expense should be granted by every foundryman, for it saves many a dollar otherwise wasted and lost, usually at a time when he can least afford it."

Passing to the use of the material thus selected, it may be asserted that a knowledge of the compositions of the irons employed will enable mixtures to be made from the analyses which will control the product. For this purpose the foundryman should know something of chemistry of the melting process, so that he may understand what changes will take place in the cupola, and he should know the composition of the scrap he uses as well as the pig. For specialties, such as car wheels, chilled rolls, malleable castings, and the like, the only way in which uniformity can be secured is by taking a daily analysis of practically every heat, especially for the silicon. In this way it has been found possible to take off 1,000 heats at a stretch without making any bad iron, the duration being only a matter of furnace repairs.

Dr. Moldenke touches upon the extent to which a proper use of chemistry in the foundry has widened the safe limits within which the daily work of the foundry can be conducted. Thus the co-relation of silicon and sulphur can be used in such a way that brands of iron containing the latter may be corrected by the presence of the former, while the total carbon in the metal may be reduced by the proper use of steel scrap. By these and similar methods materials may be used which would otherwise be considered entirely unsuitable for the production of satisfactory castings.

For many purposes the air furnace is being looked upon with increased favor for general foundry work, and in connection with the increasing use of the methods indicated by chemistry, Dr. Moldenke believes that the furnace may well replace the cupola. The absence of contact of the metal with the fuel insures a closer realization of the chemical reactions sought for in the mixture, and the improvement in the product is noteworthy.

"We Americans are said to appropriate every good idea we find on the other side of the water, and so we have taken Professor Turner's discovery of the action of silicon on the carbon in cast iron. We have taken Professor Ledebur's studies of the condition of the carbon in the malleable casting, and have pushed these inquiries far ahead in connection with our daily work. It is gratifying to see that now England and Germany are awakening to the importance of the chemistry of cast iron, and foundrymen's associations are being called to life, whose primary object is to study advanced methods of working. We wish them all possible success, and hope that their transactions may contain much new material that we can appropriate and amplify later on. A rivalry which means the freest interchange of information is a detriment to no one, and stimulates research as well as commercial enterprise. May we learn much more of the chemistry of iron in our foundry practice, and gradually clear away the doubtful portions which still remain to let us feel how little we really do know."

THE CIRCUM-BAIKALIEN RAILWAY.

COMPLETION OF THE CONNECTING LINK IN THE TRANS-SIBERIAN RAILWAY SYSTEM AROUND THE SHORE OF LAKE BAIKAL.

Glasers Annalen für Gewerbe und Bauwesen.

WITH the opening of the Circum-Baikalien section of the Trans-Siberian railway the completion of that great undertaking may be claimed, notwithstanding the fact that the Pacific terminal is at present involved in the deplorable interruptions of war.

This connecting portion of the road around the southern end of Lake Baikal has been deferred in construction beyond the rest of the railway because of the great difficulties presented, and because the traffic at the time of the opening of the line could readily be taken care of by the use of the train ferry across the lake.

Since the development of hostilities in Manchuria, and the necessity of maintaining continuous all-rail communication with the army during the winter season, efforts have been made to complete the railway connection, and the result has been the opening of the line for military service, thus prac-

tically completing the continuous railroad.

The total length of the railway connection around the lower end of the lake is 260 kilometres, and this has been divided into two separate construction undertakings. The first of these, extending from the station at Baikal around to Kultuk, a distance of 85 kilometres, offered the greatest obstacles to the work. In this portion the spurs of the Sayanskii Mountains skirt the lake, rising almost vertically from the shore to heights of more than 300 metres, and interrupted by ravines and gorges. The rock proved unsuitable for unsupported tunneling, and in nearly every case the borings required lining with masonry. In this section of 85 kilometres there were required 32 tunnels, having an aggregate length of 5.87 kilometres, and 210 bridges, viaducts and culverts. A number of deep cuttings were necessary, and these all required reinforcing with masonry retaining walls, while, as above stated, all the tunnels have been lined throughout. The longest tunnel is 800 metres in length, and all the tunnels have been made wide enough for double track, although but a single line has been laid at present. In this portion of the road the railway runs close to the shore of the lake, the tracks being at a level of 9.50 metres above the surface of the water. The second section, extending from Kultuk to Myssowsk, and connecting with the Manchurian railway at the latter point, offered fewer difficulties. The mountains here recede from the shore of the lake, so that but a single tunnel, of 80 metres in length, has been found necessary. The greatest trouble in this portion lay in the nature of the soil, this being marshy from frequent inundations from the lake, and traversed by numerous torrents running down from the mountains, necessitating bridges at points where it was difficult to secure good foundations. The railway in this portion of the route runs mainly upon an embankment, the width at the top being 5.54 metres, the sharpest curves being of 320 metres radius, and the steepest grade 1:125. In general the Circum-Baikalien section is better built than other parts of the Trans-Siberian, being laid with rails weighing 32.24 kilogrammes per metre, or about 65 pounds per yard. The bridges are steel trusses, on masonry piers, and the viaducts are built partly of steel and partly of masonry. Turnouts are provided at every 12 kilometres, permitting the operation of 14 trains in each direction every 24 hours.

In connection with the construction of the eastern section of the railway there has been built a branch line to the edge of the lake at Tanchoi, where a harbor has been constructed with complete accommodations for the great ice-breaking ferry boats now used in carrying the trains across the lake. This connection shortens the length of the lake trip for the ferry boats to about one-half of the old route from Baikal to Myssowsk, the boats making the trip only from Baikal to Tanchoi, where the coast portion of the railway is touched. There will thus always be a ferry communication available in case of any interruption upon the difficult portion of the line and it is probable that this route may be regularly used in connection with merchandise traffic, especially when, as now, the full capacity of the railway is taxed for military purposes.

The intention to double-track the entire line of the Siberian railway is apparent from the fact that all the tunnels have been made of sufficient width to accommodate a double line of track, although but a single line has been laid at present. The double tracking of the entire line is even now progressing, and the extent to which this has been accomplished will be seen when it is understood that the sidings now in existence cover more than 1,000 miles of what will ultimately be the second line of track.

Some idea of the magnitude of the work will be gathered from the data as to the amount of material handled and the cost of the construction. From data in a recent issue of *Glasers Annalen*, from which this account is taken, it appears that the cuttings alone demanded the removal of 4,484,170 cubic metres of rock, these being hewn through the spurs of the mountains, and requiring continual blasting; while the tunnels involved the blasting and removal of 3,884,920 cubic metres of rock. The embankment in the second section of the line contains 9,760,860 cubic metres of earth and rock.

The total cost of the railway is given as 52,524,000 rubles, about $27,000,000, or £5,600,000, this corresponding to about $168,000, or £35,000 per mile.

Passing to the use of the material thus selected, it may be asserted that a knowledge of the compositions of the irons employed will enable mixtures to be made from the analyses which will control the product. For this purpose the foundryman should know something of chemistry of the melting process, so that he may understand what changes will take place in the cupola, and he should know the composition of the scrap he uses as well as the pig. For specialties, such as car wheels, chilled rolls, malleable castings, and the like, the only way in which uniformity can be secured is by taking a daily analysis of practically every heat, especially for the silicon. In this way it has been found possible to take off 1,000 heats at a stretch without making any bad iron, the duration being only a matter of furnace repairs.

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ALPINE RAILWAY BUILDING.

TUNNELLING AND PERMANENT-WAY CONSTRUCTION UPON THE UPPER SECTION OF THE JUNGFRAU ELECTRIC RAILWAY.

Paul Möller—Verein Deutscher Ingenieure.

SEVERAL months ago we gave some account of the progress which had been made during the past season upon the electric railway intended to reach the summit of the Jungfrau, and permit tourists in Switzerland to make the ascent with speed and comfort. We now have a further account of the work upon this interesting piece of Alpine railroading, by Herr Paul Möller, in recent issues of the *Zeitschrift des Vereines Deutscher Ingenieure*, from which we make some abstracts.

The starting point of the road is the station Kleine Scheidegg, on the Grindelwald-Lauterbrunnen railway, this line having been opened since 1893, and much frequented by tourists since then. This point is 2,064 metres above sea level, while the summit of the Jungfrau is more than double this altitude, being 4,166 metres above the sea, or 13,668 feet. The line winds up the mountain, with grades varying from 5 to 24 per cent., and passing through a tunnel of 80 metres in length, reaches the station Eigergletscher, a distance of 2 kilometres and an altitude of 2,323 metres, where the extended view of the surrounding glacier fields begins, the peaks of the Eiger, the Mönch and the Jungfrau all being visible. From this point on there are numerous tunnels, the grade remaining at about 25 per cent. until the station Eismeer is reached, about 5½ kilometres from the starting station, and 3,162 metres altitude. Beyond this point the road is not open to passenger service, although the construction work is progressing.

Just beyond the Eigergletscher station the road enters the principal tunnel, extending, with several openings to a point directly beneath the summit, from whence the peak is to be reached by a lift operated in a vertical shaft. One of the interesting features of this portion of the work appears in the extensive chambers which are hollowed out in the mountain at the stations, and from which openings are pierced in the walls, and observation balconies provided for the use of the travelers. Thus, from the station Eigerwand, at an altitude of 2,868 metres, an extended view over the Jura is obtained, and even to the distant Black Forest beyond.

The surveys for the upper section of the railway have been fully completed in all details as far as the Jungfraujoch station, and there remains but a small portion of the work to be done to the point of the elevator shaft. It is of interest to note that a portion of the topographical work was accomplished by the methods of photogrammetry, or photographic surveying, this being especially adapted for such a location.

An interesting portion of the work is found in the shops just beyond the Eigergletscher station. Here is a small machine shop, carpenter shop, and repair shop for the rock drills. Houses for the workmen are also provided, together with storehouses for material and provisions, the whole being intended to enable the working force to remain in comfort for months at a time without communication with the valley below. The possession of electric communication with the power house enables current to be available for power and for heating, this latter being used for the melting of ice for water, and for thawing dynamite.

The tunneling is conducted with three shifts of eight hours each, the workmen coming principally from northern Italy. The boring is being performed almost entirely by electric power, very little hand work being required, and although the operators are obliged to remain at high altitudes for several months at a time there has not been any apparent development of mountain sickness.

Herr Möller describes in detail the construction of the electric locomotives and rolling stock, as well as the hydro-electric station at Lauterbrunnen, but these have already been discussed in these columns. The whole undertaking is an excellent example of the manner in which electric power development, together with applications of electric traction methods, are being applied

to open up ways of communication which could hardly have been profitably undertaken under older systems.

An interesting feature of the Jungfrau railway appears in the fact that at every point the road is made with sufficient incline to enable the train to descend by gravity alone, this insuring a safe return to the valley below in case of any accident which might cut off or interrupt the electric power.

THE EQUIPMENT OF THE ENGINEER.

A CHARACTERISTIC ADDRESS DELIVERED BEFORE THE STUDENTS OF THE INSTITUTION OF ELECTRICAL ENGINEERS.

James Swinburne—The Electrician.

LAST month we reviewed in these pages the suggestive address of Mr. Kerr, delivered before the students of the Stevens Institute of Technology, in which some of the difficulties with which the practising engineer has to contend were placed before the beginner. We now have a somewhat similar presentation of the practical side of engineering work in the form of an address by Mr. James Swinburne before the students of the Institution of Electrical Engineers. From a report of this address published in a recent issue of the *Electrician* we make some abstract and review, and a comparison between the views of two such practical men upon such similar occasions cannot fail to be of interest alike to students and to Engineers.

Upon the much-discussed subject of general and special knowledge, Mr. Swinburne takes a rather conservative position.

"Probably each man should have a general knowledge of applied physics and chemistry and mathematics, and a special knowledge of one or two subjects. The special knowledge may never come in useful; but the chances are that in the blind stumblings we call our careers a specialty may be very valuable. If you glance round at the work of some of our big men you will be surprised to see how many have made their reputation by doing one small thing, but doing it well. If a man gets to the front in one narrow subject the world credits him with knowledge of all the rest. It is, however, even easier to acquire a large general knowledge than an advanced special knowledge of one narrow subject. The specialty must not be too narrow either."

That all knowledge is valuable for the uses to which it can be put, is emphasized in a very characteristic manner. It is undoubtedly true that much time and labor has been expended in the past upon studies which were regarded at the time as worthy departments of pure science, but which have long since been abandoned because they have been shown to be based upon false principles.

"Science, for which no use has been found, or which is not applied, is called 'pure science,' whereas it is really the raw material, and should be called 'raw' or 'crude science.' There is an assumption of superiority in the term 'pure science,' and generally the term 'science' is appropriated by workers in raw science in much the same way as the term 'workingman' is appropriated to the exclusion of brain workers. There is supposed to be something noble and superior about 'raw science,' and its study is treated as the unselfish devotion to the interests of man, which is obviously entirely the wrong way round. The so-called 'scientific man' thinks that engineers and manufacturers are ignorant and unscientific, and that their practical knowledge is of no account; and that the cure for all industrial evils is more technical education, more universities and more power to the science masters. Though there are in existence a few practical science teachers they are rare. Perhaps no one would be more surprised than the average science master if you told him he was unpractical, and was, by his attitude and example, hindering science. He does not mean to. He is as keen as possible to do just the reverse, and is generally exceedingly anxious for the spread of science or technology; but, unfortunately, he has got a wholly wrong view of the relations of science and business. There is no more baneful influence on the technical advancement of this country than the Royal Society ideal in science."

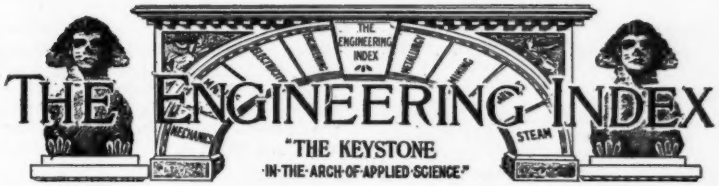
The keynote of Mr. Swinburne's address, however, lies in the position which he takes concerning the relations of the scientific engineer and the business man.

"I would earnestly urge any of my hearers who has the idea that there is something noble and superior about 'raw science,' or who thinks little of business men, to get rid of all such notions if he hopes ever to get on. If you look round the electrical industry, or round the industries generally, who are at the top? Always the business man. The men at the head of large industries generally know very little science. A man may run a large electrical industry with the most vague ideas as to the true relation of the electrostatic and electromagnetic systems of units; in fact, he may think power, force and energy are very much the same kind of thing if looked at in a broad common-sense way without any scientific prejudice. If he wants good technologists he employs them. If he wants practical men who can take commercial responsibility he pays good salaries; if he wants men full of book knowledge he pays low salaries, but he does not generally want them. Raw scientists, to coin a horrible word for a most estimable class, tell him he knows nothing about science, and therefore does not know how to run a scientific business, and tell him to subscribe to universities, which are so inefficiently worked that they have to beg, like hospitals, and to employ young men from the technical colleges. He either takes no notice or he gets annoyed at their superior attitude, and discharges a couple of scientific men and puts their saved wages toward the salary of a new practical chauffeur, and enjoys himself."

"A man's value to the world at large may generally be roughly estimated by the income he earns. Where position is earned at the same time, the money income is in proportion less for a given usefulness; but taking such disturbing elements into account, the rule is broadly true. The business man comes out far away above the engineer. He employs the engineer; the scientific man is his servant. Just as the raw scientist looks down on the engineer, and the engineer looks down on the business man, so the business man has a contempt for the engiiness; and the engineer in his turn looks on the raw scientist as an unpractical crank. So much is this the case that the business man will not trust the engineer more than he can help. He assumes that if you know anything about anything you cannot possibly be a business man."

That the engineer cannot be a successful business man is by no means the idea everywhere. In fact, it is now very generally recognized in the United States that a scientific training is an excellent qualification for a business career. The positions of the heads of great railroads, manufacturing companies, and industrial enterprises are in many instances filled by men who have risen from engineering positions, and who are applying the methods of engineering science to commercial problems. Productive commercial enterprises have come to be so closely identified with engineering operations and methods that it is beginning to be very well recognized that there is no training possible which fits a man better for business success than the training of the engineer.

An excellent example of this fact is seen in the manner in which men with engineering training have entered the great workshops of the United States and have, by revolutionizing and reorganizing the methods devised by the older business men, succeeded in increasing the output, improving the quality of the product, and curtailing the losses, simply by an intelligent application of scientific engineering methods to operations formerly conducted according to the ideas of the old-time business man. In England the "production engineer" has not yet attained the prominence which exists in America, but he is not altogether unknown, and there is ample room for him and his work in a field as yet all too little cultivated.



The following pages form a DESCRIPTIVE index to the important articles of permanent value published currently in about two hundred of the leading engineering journals of the world—in English, French, German, Dutch, Italian, and Spanish, together with the published transactions of important engineering societies in the principal countries. It will be observed that each index note gives the following essential information about every article.

(1) The full title,
(2) The name of its author,
(3) A descriptive abstract,
(4) Its length in words,
(5) Where published,
(6) When published.

We supply the articles themselves, if desired.

The Index is conveniently classified into the larger division of engineering science, to the end that the busy engineer and works manager may quickly turn to what concerns himself and his special branches of work. By this means it is possible within a few minutes' time each month to learn promptly of every important article, published anywhere in the world, upon the subjects claiming one's special interest.

The full text of any article referred to in the Index, together with all illustrations, can usually be supplied by us. See the "Explanatory Note" at the end, where also the full titles of the journals indexed are given.

DIVISIONS OF THE ENGINEERING INDEX.

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CIVIL ENGINEERING

BRIDGES.

Arches.

The Economical Construction of Large Stone Bridges (Construction Economique des large Ponts en Pierre). M. Sejourné. Showing the advantages of using two narrow arches instead of a single wide arch, as in the case of the Luxembourg and Toulouse bridges. 4000 w. Rev Gen d Chem de Fer—Oct., 1904. No. 66229 G.

Bridgework.

The Anatomy of Bridgework. W. H. Thorpe. An illustrated article dealing with cases that have come under the writer's personal notice. The present number considers girder bearings, main girders, and plate-webs. 4000 w. Engng—Nov. 18, 1904. Serial. 1st part. No. 66384 A.

Cantilever.

The Erection of the Double Track Mingo Cantilever Bridge Over the Ohio River. An illustrated description of an unusually difficult undertaking; a 700 ft. channel span crossing the Ohio River. 2000 w. Eng Rec—Nov. 26, 1904. Serial. 1st part. No. 66343.

Drawbridge.

The Calumet River Drawbridge, Balti-

We supply copies of these articles. See page 710.

more and Ohio R. R. Illustrated description. 1000 w. Eng Rec—Nov. 26, 1904. No. 66349.

Highway Bridge.

The Bellows Falls Highway Bridge. An illustrated description of a large highway arch span across the Connecticut River, the only long-span arch with suspended floor in the United States. 2500 w. Eng Rec—Nov. 5, 1904. No. 65948.

The Comparative Economy of Various Types of Highway Bridges. C. B. Wing. Outlines a method for determining the most economical bridge for a given location. 2000 w. Jour Assn of Engng Socs—Sept., 1904. No. 66170 C.

Maastricht.

The Erection of the Bridge Over the Maas at Maastricht (Herstellings-werken aan de Brug over de Maas te Maastricht). Ch. Driessen. Illustrated account of the erection of a lattice truss railroad bridge at Maastricht, Holland, the two principal spans being 100 metres long each. 4000 w. De Ingenieur—Oct. 8, 1904. No. 66278 D.

Reconstruction.

The Swale Bridge. Illustrated description of an interesting piece of reconstruction work on the Southeastern and Chatham Railway. A bascule bridge span was replaced by a Scherzer rolling-lift type. 500 w. Engng—Nov. 11, 1904. No. 66300 A.

Reinforced Concrete.

Crossing Bridge of Reinforced Concrete (Bahnübergangssteg aus Betoneisen). Ludwig Stuppacher. Illustrating a Monier arch foot bridge over double-track railway line, with details of construction. 6000 w. 2 plates. Oesterr Woschenschr f d Oeffent Baudienst—Oct. 15, 1904. No. 66265 D.

Reinforced Concrete Bridge Over the Isar at Grünwald Above Münich (Strassenbrucke in Eisenbeton über die Isar vei Grünwald Oberhalb München). Illustrating and describing a highway bridge with two spans of 70 metres each, with hinges at the crown and springings. Three articles. 3000 w. Deutsche Bauzeitung—Oct. 5, 12, 19, 1904. No. 66266 each B.

Tests of a Ferro-Concrete Bowstring Bridge. Illustrated article reporting tests made of a 60-ft. bowstring bridge erected at Purfleet. 900 w. Engng—Oct. 28, 1904. No. 65984 A.

See also Civil Engng., Construction.

Renewals.

Renewing Bridges on the West Shore. An illustrated article giving information regarding the extensive bridge renewals in the course of improving this road for heavy traffic. 1500 w. R R Gaz—Vol. XXXVII, No. 23. No. 66160.

Rhine.

New Bridge Near Mayence. Illustrations, with brief description of a bridge making a direct connection between the railways on the right and left banks of the Rhine. 700 w. Engr, Lond—Nov. 11, 1904. No. 66303 A.

Sunderland.

New Railway and Road Bridge Over the River Wear at Sunderland. Francis E. Harrison. Illustrates and describes a new bridge for both railway and road purposes, with main span of 330 feet. 2000 w. Transport—Nov. 18, 1904. No. 66353 A.

Suspension.

A New Type of Rigid Suspension Bridge. Translation of an article by Commandant Gisciard, in the *Genie Civil*. Illustrated description of a type of which three bridges have been built in the French Congo, and one is under construction in the Pyrenees. 3000 w. Eng Rec—Nov. 5, 1904. No. 65951.

The Elisabeth Suspension Bridge at Budapest (Le Pont Suspendu Elisabeth à Budapest). A. Bidault des Chaumes. A fully illustrated account of the new eyebar suspension bridge of 290 metres span across the Danube. 2500 w. 1 plate. Genie Civil—Oct. 15, 1904. No. 66211 D.

Thebes.

The Thebes Bridge. Illustrated description of a double-track railroad bridge across the Mississippi River, now nearing completion. 1500 w. Eng Rec—Nov. 12, 1904. No. 66026.

Williamsburg Bridge.

Electrifying the New Williamsburg Bridge. Brief illustrated description of electrical equipment of the double tracks on this East River bridge at New York. 600 w. St Ry Jour—Nov. 19, 1904. No. 66182 C.

Wreck.

Repairing a Wrecked Drawbridge Over the Maumee River at Toledo. An illustrated account of the wrecking of a drawbridge on the Wheeling & Lake Erie R. R. by a steamer, and the repairs. 1000 w. Eng Rec—Nov. 19, 1904. No. 66152.

CONSTRUCTION.

Buildings.

The Structural Design of Buildings. Discussion of a paper by C. C. Schneider. 12000 w. Pro Am Soc of Civ Engrs—Nov., 1904. No. 66368 E.

Dining Hall.

Steel Details of a Large Dining Hall. Illustrates and describes details of the dining hall for the Middletown State Hospital for the Insane. 1600 w. Eng Rec—Nov. 5, 1904. No. 65952.

We supply copies of these articles. See page 719.

Efflorescence.

On the Saline Efflorescence of Bricks. Oscar Gerlach, in the *Brickbuilder*. Discusses the causes leading to it, and the practical means of avoiding the same. 3000 w. Stevens Ind—Oct., 1904. Serial. 1st part. No. 66409 D.

Floors.

Fireproof Floor Construction. J. T. Montgomery. Remarks on concrete construction, explaining the application of this material to the protection of structural steel in buildings, its advantages and disadvantages. Ills. 2700 w. Jour W Soc of Engrs—Oct., 1904. No. 66094 D.

Standard Floor Arch Construction. E. V. Johnson. General remarks on the standard floor arch construction, with statement of the advantages of the standard steel and tile construction. Discussion. 7700 w. Jour W Soc of Engrs—Oct., 1904. No. 66095 D.

Pile Driving.

Observations on Driving Piles with a Steam Hammer. J. J. Welsh. Describes work in San Francisco, explaining the conditions. 1000 w. Jour Assn of Engng Socs—Sept., 1904. No. 66172 C.

Reinforced Concrete.

A New Method of Building Construction. S. Giletti. Illustrates and describes a method of building walls, partitions and floors in which the metallic frame is inserted in flues left open for this purpose, the walls being built first, and then filled in, binding the whole in a solid mass. 1500 w. Jour Assn of Engng Socs—Sept., 1904. No. 66168 C.

A Rèsumè of Some Tests on Concrete Steel Beams. J. Kahn. A report of tests made by the writer, repeating tests made by Prof. A. M. Talbot. 2500 w. Cement—Nov., 1904. No. 65954 C.

Concrete Steel. M. C. Couchot. A short description of this system of construction, its recent applications in the United States and its advantages. 1800 w. Jour Assn of Engng Socs—Sept., 1904. No. 66167 C.

The Parkville Concrete-Steel Substation of the Brooklyn Rapid Transit Co. Illustrated detailed description. 3000 w. Eng Rec—Nov. 26, 1904. No. 66345.

See Also Civil Engineering, Bridges.

Roads.

Road Building in the Far North. C. W. Purington. An account of road building in Alaska, the conditions, difficulties, costs, etc. 1600 w. Eng & Min Jour—Nov. 24, 1904. Serial. 1st part. No. 66326.

Steel Framing.

The Steel Framing of the New Amsterdam Theatre, New York. Illustrated description of interesting structural features in a steel-cage fireproof building covering about 17,500 sq. ft. of ground surface. 1800 w. Eng Rec—Nov. 19, 1904. Serial. 1st part. No. 66155.

Steel-Work.

Special Steel-Work in Orchestra Hall, Chicago. Drawings, photographs and description. 3500 w. Eng News—Nov. 3, 1904. No. 65923.

Tunnels.

Great Northern Tunnel at Seattle. Illustrated detailed description of the tunnel, nearly a mile long, being driven under the business section of the city. 1300 w. R R Gaz—Vol. XXXVII, No. 22. No. 66005.

The Construction of the Simplon Tunnel (Der Bau des Simplon Tunnels). Paul Möller. A description of the methods of working, drainage, ventilation, and timbering of the later portions of the tunnel. 4500 w. Zeitschr d Ver Deutscher Ing—Oct. 29, 1904. No. 66205 D.

The Remarkable Progress of the Hudson River Tunnel for the New York and New Jersey R. R. Co. A brief illustrated account of the methods of construction and the progress of the work. 1000 w. Eng News—Nov. 10, 1904. No. 65999.

Underpinning.

Concealed Underpinning for a New York Residence. Describes the damage to a building on the corner of 38th st. and Park ave., New York, caused by the construction of the tunnel for the Rapid Transit Ry., and the method of underpinning devised to support the building until the new foundations are built. Ills. 900 w. Eng Rec—Nov. 26, 1904. No. 66347.

MATERIALS OF CONSTRUCTION.

Asphalt.

Asphalt. Thomas B. Stillman. Its occurrence, composition, adulterations, and commercial uses, with schemes for its analysis. 1200 w. Stevens Ind—Oct., 1904. No. 66407 D.

Cement.

Manufacture and Testing of Portland Cement. C. J. Wheeler. Reviews briefly the history of cement manufacture, describing present practice and giving information of interest. 4000 w. Jour Assn of Engng Socs—Sept., 1904. No. 66169 C.

Notes on Lutes and Cements. Samuel S. Sadtler. Treats of kinds of lutes and cements most likely to be used by engineers, and arranged according to the intended application. 2800 w. Pro Engrs' Club of Phila—Oct., 1904. No. 66067 D.

The Cement Exhibits at the St. Louis Exhibition. Illustrated description of the cement building, model testing laboratory, and other exhibits. 3000 w. Eng News—Nov. 10, 1904. No. 65996.

We supply copies of these articles. See page 719.

Cement Mill.

A Gravity Cement Mill in the Pyrenees. G. M. Peek. A fully illustrated account of the construction and mechanical equipment of a mill driven by hydraulic power, and utilizing gravity in the movement of material. 3000 w. Engineering Magazine —Dec., 1904. No. 66285 B.

Fire-Brick.

Refractoriness of Some American Fire-Brick. R. F. Weber. Gives results obtained in testing a series of fire-brick from different parts of the country, in order to determine the relation of their chemical composition, refractoriness and texture. 3500 w. Trans Am Inst of Min Engrs—Sept., 1904. No. 66359.

Plaster.

Plaster-of-Paris (Le Plâtre). J. Malette. A general discussion of the nature and properties of calcined gypsum as a material of construction. 3000 w. Revue Technique—Oct. 25, 1904. No. 66221 D.

Reinforced Concrete.

See Civil Engineering, Bridges, Construction.

Road Materials.

The Cementing Power of Road Materials. Logan Waller Page and Allerton S. Cushman. Reports the results of researches made by the Bureau of Chemistry, U. S. Dept. of Agriculture. 3500 w. Eng News—Nov. 17, 1904. No. 66131.

Timber Preservation.

Two New Timber Preservation Processes at the St. Louis Exhibition. Describes the Rueping process, and Giussani process. 1800 w. Eng News—Nov. 17, 1904. No. 66127.

MEASUREMENT.

Surveying.

A Universal Angle-Measuring Instrument (Universal Winkelinstrument). A. Mayer and E. Wiesmann. Illustrating an improved form of engineer's transit, adapted for tunneling and general railway work, and designed in connection with the work on the Simplon tunnel. 2000 w. Schweiz Bauzeitung—Oct. 15, 1904. No. 66250 B.

Wind Pressure.

Probable Wind Pressure Involved in the Wreck of the High Bridge Over the Mississippi River, on South Avenue, St. Paul, Minn., August 20, 1904. C. A. P. Turner. An illustrated article describing the bridge, and outlining the collapse, with calculation of the pressure. 2000 w. Pro Am Soc of Civ Engrs—Nov., 1904. No. 66366 E.

MUNICIPAL.

Joints.

The Use of Sulphur for Sewer-Pipe Joints in Wet Trenches. E. S. Rankin. Describes a plan used by Alexander Potter, of joining pipes with a mixture of melted sulphur and fine sand, and since used by the writer experimentally for securing water-tight work. 1700 w. Munic Engng—Nov., 1904. No. 65902 C.

Laboratory.

A Municipal Laboratory for Testing Asphalt and Cement. W. H. Broadhurst. Illustrated description of a plant designed for testing asphalts, paving materials, cements, etc., and the facilities for testing. 2000 w. Munic Engng—Nov., 1904. No. 65900 C.

Pavements.

Granite Asphalt Paving (Le Granite Asphalte). Col. G. Espitallier. Describing the use of a mixture of crushed granite and asphalt for surfacing pavements, as used in the Place de l'Opera, at Paris. 1500 w. Génie Civil—Oct. 29, 1904. No. 66215 D.

Tests for Wood Paving Blocks. F. A. Kummer. Considers in detail the specifications prepared by George W. Tillson for work of this class. 2000 w. Munic Engng —Nov., 1904. No. 65901 C.

Refuse.

The Disposal of Municipal Refuse. F. K. Rhines. Discusses the various classes of refuse and the difficulties of disposing of each, and why some methods succeed while others fail. 6500 w. Jour Assn of Engng Socs—Oct., 1904. No. 66400 C.

Sewage Disposal.

Sewage Disposal for Small Cities and Towns. T. Chalkley Hatton. Outlines several systems used for sewage purification, the choice depending on the character of the sewage. 3300 w. Munic Engng—Nov., 1904. No. 65897 C.

Sewage Disposal. J. N. McClintock. Describes a plant at a seaside cottage to prevent pollution of the water where seabathing is permissible. 1200 w. Munic Engng—Nov., 1904. No. 65898 C.

The Disposal of Sewage Sludge at Saltley, England. George A. Hart. Illustrated description of a recent experience in sewage and sludge disposal at the Saltley outfall works of the Birmingham, Tame and Rea District Drainage Board. 3500 w. Eng Rec—Nov. 5, 1904. No. 65949.

Sewage Testing.

The Sewage Testing Station at Columbus, Ohio. John H. Gregory. Brief remarks on the extensive improvements planned, with illustrated description of the testing station. 2500 w. Eng Rec—Nov. 19, 1904. No. 66153.

Sewers.

Some Examples of Recent Main Sewer

We supply copies of these articles. See page 719.

Construction by the City of Philadelphia. C. H. Ott. Illustrates and describes the types of construction. Discussion. 2200 w. Pro Engrs' Club of Phila—Oct., 1904. No. 66066 D.

The Cleaning and Flushing of Sewers. Discussion by the Sanitary Section of the Boston Society of Civil Engineers at the meetings of March 2 and April 13, 1904. 23400 w. Jour Assn of Engng Socs—Oct., 1904. No. 66399 C.

The Design of a Main Outfall Sewer. Notes from a paper by W. H. Haigh, in the Pro. of the Inst. of Civ. Engrs., concerning a sewer leading to Bristol Channel from one of the three drainage districts of Cardiff. 4000 w. Eng Rec—Nov. 19, 1904. No. 66154.

The Sewerage System of Little Rock, Ark. Walter F. Reichardt. Explains the method of making improvements in this city, and the present condition of the sewerage system. 2200 w. Munic Engng—Nov., 1904. No. 65899 C.

Sewer Ventilation.

The Shone System of Fan Ventilation of Sewers at Darley Abbey and at Leicester, England. Describes a system of sewer ventilation by means of a fan on an extraction shaft and specially designed air inlets at the top of vertical shafts. 2500 w. Eng News—Nov. 24, 1904. No. 66334.

WATER SUPPLY.

Coolgardie.

The Coolgardie Water Works. Illustrated description of the water works scheme for supplying the mines of Western Australia. 3500 w. Sci Am Sup—Nov. 12, 1904. No. 66010.

Corrosion.

Electrolytic Corrosion of Water Pipes at Bayonne, N. J. Abstract of results of an investigation made by A. A. Knudson, which reveals serious conditions as to stray electric railway currents and electrolytic corrosion of underground metals. Ills. 3000 w. Eng News—Nov. 17, 1904. No. 66130.

Dam.

Cataract Dam for the Additional Water Supply of Sydney, N. S. W. Illustrates and describes new works to increase the supply for this Australian city, and the methods of construction. 2700 w. Eng Rec—Nov. 5, 1904. No. 65947.

The Charles River Dam and Lock at Boston. John N. Ferguson. Illustrated article showing the location, arrangement and style of construction of the dam and work in connection. 2500 w. Eng Rec—Nov. 26, 1904. No. 66346.

Extensions.

The Odessa Water Works. An illustrated article describing new extension to supplement the old plant at Odessa, Russia, with the most modern and economical machinery. 1500 w. Engng—Nov. 4, 1904. No. 66053 A.

Filtration.

The Mechanical Filters of the Hackensack Water Company. Illustrated description of the purification works. 3000 w. Eng Rec—Nov. 12, 1904. Serial. 1st part. No. 66028.

The Roofing of the Washington Filters. E. D. Hardy. Illustrated description of the methods of construction. 1500 w. Eng Rec—Nov. 5, 1904. No. 65950.

Frozen Pipes.

Thawing Out Frozen Water Pipes Electrically. William Maver, Jr. Reviews plumbers' methods of thawing, and gives an illustrated description of the electrical method and related information of interest. 3000 w. Cassier's Mag—Nov., 1904. No. 66063 B.

Ground Water.

The Progressive Sinking of the Ground Water Level and Artificial Ground Water Supplies. Prof. J. Gustav Richert. A discussion of the effect of wells on ground water supplies, and concluding that artificial infiltration is the best solution of the problem. Ills. 2000 w. Eng News—Nov. 24, 1904. No. 66333.

The Sources of the Utrecht Water Supply (De Prise d'Eau van de Utrechtsche Waterleidung). P. E. Rijk. With plan of the location of the pipe, wells and chart of the ground-water levels from 1885 to 1904. 2000 w. 1 plate. De Ingenieur—Sept. 24, 1904. No. 66277 D.

Lead Pipe.

The Use of Lead Pipe for Conveying Drinking Water (Verwendung von Bleiröhren bei Trinkwasserleitungen). Adolf Siegmund. An examination of the conditions under which drinking water may be rendered unwholesome by passing through unlined lead pipes. 4000 w. Zeitschr d Oesterr Ing u Arch Ver—Oct. 21, 1904. No. 66222 D.

Mains.

Scraping Water Mains at Melbourne. Information concerning this work taken from a paper by Edgar G. Ritchie, published by the Inst. of Civ. Engrs. 1500 w. Eng Rec—Nov. 26, 1904. No. 66344.

Pumping Machinery.

See Mechanical Engng., Hydraulics.

Reservoirs.

The Failure of a Small Brick Reservoir at Winston, N. C. J. L. Ludlow. Brief, illustrated description. 900 w. Eng News—Nov. 17, 1904. No. 66132.

We supply copies of these articles. See page 719.

The New High Service Reservoir at Holyoke, Mass. Illustrates and describes a recently completed dam and reservoir to supply water to the elevated portions of this city of 50,000 inhabitants. 1800 w. Eng Rec—Nov. 26, 1904. No. 66348.

River Pollution.

The Collection of River Waters for Investigation (Probeentnahme apparate für Flussuntersuchungen). Dr. Schumacher. An exhaustive account of the various devices for taking samples of river water for examination for hygienic purposes. Three articles. 7000 w. Gesundheits Ingenieur—Sept. 20, 30, Oct. 10, 1904. No. 66262 each B.

The Pollution of the Passaic River and Its Prevention. Ernest Adams. Gives a full account of the trouble from the pollution of this river of New Jersey, and the correction. 3500 w. Munic Engng—Nov., 1904. No. 65896 C.

Vienna.

The Water Supply of Vienna (Die Wasserversorgung Wiens). Josef Riedel. A general account of the various sources of supply, with map and profiles. 3000 w. 2 plates. Oesterr Wochenschr f d Oeffend Baudienst—Oct. 22, 1904. No. 66279 D.

Water Tower.

The Million-Gallon Water Tower of the East Providence Water Company. Illustrated description of a very large new tower which furnishes storage for fire protection and other purposes. 1700 w. Eng Rec—Nov. 12, 1904. No. 66031.

WATERWAYS AND HARBORS.

Canals.

Preliminary Engineering Work on the New York Barge Canal Improvements. Reviews a manual of instructions recently issued by H. A. Van Alstyne, State Engineer, for preliminary work on the improvement of the Erie, Oswego and Champlain Canals. 2200 w. Eng Rec—Nov. 12, 1904. No. 66029.

The Projected New Canal from the River Rhine to the City of Hanover. Describes the project, and gives a summary of the advantages promised. Map. 1600 w. Ir & Coal Trds Rev—Nov. 4, 1904. No. 66046 A.

Channel Ports.

The Principal Ports on the Channel (Les Principaux Ports de la Manche). R. Bonnin. Describing the improvements completed and in progress at the ports used in connection with the traffic between France and England. Serial. Part I. 2000 w. Revue Technique—Oct. 25, 1904. No. 66218 D.

Dock.

Floating Dock of 11,500 Tons Capacity (Schwimmdock von 11,500 t Tragfähigkeit). W. Kaemmerer. Describing a new floating dock built by the Gut-hoffnungohütte for use at Hoboken, near Antwerp. 1500 w. 1 plate. Zeitschr d Ver Deutscher Ing—Oct. 22, 1904. No. 66202 D.

Dock Yards.

One of Japan's Dock Yards. Illustration, with description of the Mitsu Bishi dock yard and engine works at Nagasaki. 1500 w. Stevens Ind—Oct., 1904. No. 66404 D.

Dredges.

Combined Bucket and Suction Dredge Constructed for the Government of Uraguay. Illustrated description of this interesting self-propelled suction dredge. 1000 w. Marine Engng—Nov., 1904. No. 65852 C.

The Steam Dredge Vulcan. Illustrated description of a powerful dredger designed to meet the requirements of the Mersey Dock and Harbor Board for deep dredging in hard material, and for working close up to the dock and quay walls. 1200 w. Engr, Lond—Oct. 28, 1904. No. 65986 A.

Dry-Docks.

Temporary Dry-Docks for Rapid Construction. V. E. Timonoff. Read before the Int. Engng. Cong. at St. Louis. Indicates one of the possible solutions of repairing damaged vessels, describing a method of constructing a temporary drydock. 2800 w. Marine Engng—Nov., 1904. No. 65854 C.

The Development of Dry-Dock Pumping Machinery. J. S. Shultz. With numerous illustrations showing the increasing and advantageous use of centrifugal pumps in dry-dock operation. 3500 w. Engineering Magazine—Dec., 1904. No. 66284 B.

Mississippi.

The Reclamation of River Deltas and Salt Marshes. J. Francis Le Baron. Shows the desirability of reclaiming such lands, especially at the mouth of the Mississippi, and along the whole seaboard. An illustrated study of the treatment. 8500 w. Pro Am Soc of Civ Engrs—Nov., 1904. No. 66367 E.

Narvik.

The Railway Terminus and Port at Narvik, Norway (Le Chemin de Fer el le Port de Narvik). Charles Delgobe. An account of the important harbor works at the Atlantic terminal of the Luleo-Narvik railway, communicating with the iron ore deposits of Lapland. 3000 w. 1 plate. Génie Civil—Nov. 5, 1904. No. 66216 D.

We supply copies of these articles. See page 719.

ELECTRICAL ENGINEERING

COMMUNICATION.

Aerial Wires.

Lightning Rods, Wireless Telegraphy and the Dispersion of Fogs by Electricity. A. Frederick Collins. A short review of the use of wires for the first two purposes, with comparison with the third use named. Describes the investigations for the dispersion of fogs. 2800 w. Elec Wld & Engr—Nov. 26, 1904. No. 66376.

Alaska.

The Alaskan Telegraph. George C. Maynard. The history of the Alaskan telegraph from its inception in 1865 to its successful working in October, 1904. Ills. 4200 w. Elec Rev, N. Y.—Nov. 12, 1904. No. 66034.

Cables.

Methods of Cable-Laying. Leonard Andrews. A summary of the advantages and disadvantages of some of the systems that have been most largely used. 1400 w. Elec Engr, Lond—Nov. 18, 1904. No. 66380 A.

The Laying of the Commercial Pacific Cable. Frank P. Medina. Describes points of design and construction, laying and maintenance of submarine cables, with special reference to the Commercial Pacific Cable Company's cable between San Francisco and Manila. 3500 w. Jour Assn of Engng Socs—Sept., 1904. No. 66162 C.

Conductors.

The Transposition of Electrical Conductors. Frank F. Fowle. Mathematical and practical discussion of the transposition of telephone and of power circuits to prevent inductive interferences and crosstalk. 4400 w. Trans Am Inst of Elec Engrs—Nov., 1904. No. 66090 D.

Printing Telegraph.

Siemens & Halske Printing Telegraph or Telecryptograph. L. Ramakers. Illustrated detailed description of this automatic telegraphic system. 2500 w. Sci Am Sup—Nov. 19, 1904. No. 66116.

Space Telegraphy.

The Installation of Wireless Telegraphy at the Marine Yard at Amsterdam (De Inrichtung voor Draadlooze Telegrafie aan de Marinewerf te Amsterdam). J. C. van Iterson. A general review of the present status of space telegraphy, with special reference to the Amsterdam installation. 3000 w. De Ingenieur—Sept. 10, 1904. No. 66274 D.

Thermo-Electric Receivers for Wireless Telegraphy and Telephony. Illustrates and describes some new and interesting arrangements devised by Prof. André Blondel. 2000 w. Sci Am Sup—Nov. 12, 1904. No. 66011.

Wireless Telegraphy on Mail Steamers. Emile Guarini. An account of how secrecy is secured on the Belgian mail packets. 1700 w. Elec Rev, N. Y.—Sept. 19, 1904. No. 66157.

DISTRIBUTION.

Alternating Current.

The Superiority of Alternating Current for the Supply of Current to Large Cities. Dr. Gotthold Stern. Abstract of a paper read before the St. Louis Int. Elec. Cong. Presents arguments favoring the alternating current. Also editorial. 6500 w. Elect'n, Lond—Oct. 28, 1904. No. 65980 A.

Cables.

The Theory of the Heating of Cables (Zur Theorie der Kabelerwärmung). J. Teichmüller. Deriving formulas for use in computing the rise in temperature of underground cables for various currents. 4000 w. Elektrotech Zeitschr—Nov. 3, 1904. No. 66239 B.

Conducting Systems.

Grounded Transmission Mediums. J. Stanley Richmond. This first of a series of articles is mainly historical, referring principally to England. Succeeding articles will deal with earth potential measurements, track drops, stray transmission, tracks and bonding. 1800 w. Elec Rev, N. Y.—Nov. 26, 1904. Serial. 1st part. No. 66339.

Faults.

Notes on Faults in Small Lead-Covered Wires. Donald Smeaton Munro. Discusses dangers due to defects of manufacture, and disadvantages after erection. Ills. 1400 w. Elec Rev, Lond—Oct. 28, 1904. No. 65979 A.

Networks.

The Computations for Open Networks (Die Berechnung Offener Stromverzweigungen). Dr. E. Müllendorff. Deriving formulas for proportioning the members of a distribution network so that the volume of the conductors shall be a minimum. 2000 w. Zeitschr f Elektrotechnik—Oct. 16, 1904. No. 66244 D.

Relay.

An Alternating Current Relay for Low Frequencies. Frank F. Fowle. Describes an invention of the writer, designed to operate on circuits of 16 2/3 cycles with a very small consumption of energy. 1200 w.

We supply copies of these articles. See page 719.

Elec Wld & Engr—Nov. 19, 1904. No. 66185.

Safety Appliances.

The Construction of Electric Safety Appliances for Weak Currents (Beitrag zur Konstruktion Elektrischer Sicherungen für Schwachstromanlagen). Hans Carl Steidle. A coherer is employed to operate a cut-out in case of any sudden change in current. 3500 w. Elektrotech Zeitschr—Nov. 3, 1904. No. 66240 B.

Switches.

American Switch Systems (Ueber Amerikanische Schaltanlagen). Artur Hruschka. A general account of American switchboard construction as applied in traction plants, long-distance transmission systems, and general service. Two articles. 7000 w. Zeitschr d Oesterr Ing u Arch Ver—Oct. 28, Nov. 4, 1904. No. 66223 each D.

Wiring.

Some Hints on Conduit Work. T. F. McMackin. Illustrated discussion of some of the difficulties met with. 1100 w. Am Elect'n—Nov., 1904. No. 65911.

ELECTRO-CHEMISTRY.

Anode Films.

Colloidal Precipitation Upon Aluminium Anodes. William Roy Mott. An explanation of phenomena in the anode film, based on extended experimental investigations. 3000 w. Elec-Chem Ind—Nov., 1904. No. 65883 C.

Electric Furnaces.

Refractory Materials in Electrical Resistance Furnaces. F. A. J. Fitzgerald. Deals with finding a satisfactory refractory material for lining electric furnaces, giving much information concerning methods of employing the materials recommended. 6000 w. Elec-Chem Ind—Nov., 1904. No. 65882 C.

Electric Smelting.

See Mining and Metallurgy, Iron and Steel.

Electrolysis.

Some Examples of Catalytic Action in Electrolysis. C. J. Thatcher. Illustrates the use of catalytic agents in analyzing electrode processes; and the practical use to which such agents may be put in synthetic electrolyses. 1800 w. Elec-Chem Ind—Nov., 1904. No. 65884 C.

The Theory of the Separation of Metals from Rapidly Moving Electrolytes (Zur Theorie der Metallabscheidung aus Stark Bewegten Elektrolyten). R. Amberg. Showing the influence of current density, degree of concentration and speed of circulation upon the rate of deposit. 1800 w. Zeitschr f Elektro-Chemie—Nov. 4, 1904. No. 66248 G.

Electro-Metallurgy.

An Electrochemical Process for the Treatment of Silver Sulphides and Gold Ores. M. Vaygouny. An account of experimental investigations made upon ores which carry their values chiefly as silver sulphides with certain amounts of gold. 3300 w. Elec Rev, N. Y.—Nov. 5, 1904. No. 65937.

Electric Furnace for the Metallurgy of Copper. Translated from *La Nature*. Brief, illustrated account of the invention of M. Imbert de Vanoy. 600 w. Sci Am Sup—Nov. 26, 1904. No. 66310.

Storage Batteries.

See Electrical Engineering, Generating Stations.

ELECTRO-PHYSICS.

Atmospheric Resistance.

The Law of Atmospheric Resistance to Electric Discharges (Ueber das Elektrische Durchschlagsgesetz für Atmosphärische Luft). Hugo Grob. A study of experiments made at the Oerlikon Works, in Switzerland, with pressures up to 105,000 volts. 1800 w. Elektrotech Zeitschr—Nov. 10, 1904. No. 66241 B.

Radio-Activity.

On the Radio-activity of Natural Waters. Bertram B. Boltwood. Describes a method for the quantitative determination of the radio-active gas contained in a water and a convenient standard for measurement and comparison. Ills. 4000 w. Am Jour of Sci—Nov., 1904. No. 65886 D.

Testing.

Magnetic Testing of Iron and Steel. Statements from the report of the committee of the American Society for Testing Materials appointed to investigate the magnetic testing of iron and steel. 1500 w. Elec Wld & Engr—Oct. 29, 1904. No. 65872.

Transformer Iron.

The Testing of Transformer Iron. Lancelot W. Wild. Remarks on the wattmeter method of testing transformer iron, describing the apparatus used at the Westminster Electrical Testing Laboratory. 1600 w. Elect'n, Lond—Nov. 11, 1904. No. 66195 A.

Wattless Current.

A Protest on Behalf of Wattless Current. E. J. Willis. A discussion of the theory of alternating currents with diagrams showing how the expression for their energy should be regarded. 2400 w. Stevens Ind—Oct., 1904. No. 66406 D.

GENERATING STATIONS.

Cheltenham.

Cheltenham Electrical Undertaking. Full text of the report of James Swin-

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burne on the municipal plant at Cheltenham, England, with editorial comment. 7200 w. Elec Engr, Lond—Nov. 18, 1904. No. 66381 A.

Dynamos.

The Unipolar Dynamo. Abstract translation of a paper by J. Seidener, in the *Zeitschrift für Elektrotechnik*. An illustrated discussion of these machines, and especially with reference to their combination with steam turbines. 1300 w. Elec Rev, Lond—Nov. 18, 1904. No. 66382 A.

The Unipolar Dynamo (Die Unipolarmaschine). J. Seidener. Describing a double-disc single-pole dynamo adapted for high rotative speeds, and hence for direct connection to steam turbines. 2500 w. Zeitschr f Elektrotechnik—Oct. 23, 1904. No. 66245 D.

Generating Set.

Electric Generating Set by the Delaunay-Belleville and Eclairage Electrique Companies (Groupe Electrogène des Sociétés Delaunay-Belleville et l'Eclairage Electrique). Ch. Dantin. Illustrating the 1500 h. p. quadruple-expansion engine, and Labour alternator exhibited at St. Louis. 1500 w. 1 plate. Génie Civil—Oct. 29, 1904. No. 66214 D.

Hydro-Electric.

Chaux-de-Fonds — Lode Hydraulic Plant. C. L. Durand. Illustrated description of a Swiss plant using the high-potential direct-current system, with generators and motors in series. 3200 w. Elec Rev, N. Y.—Nov. 5, 1904. No. 65936.

Extension of Dam and Paving of River Bank at Des Moines, Ia. C. B. Burdick. Illustrates and describes the hydraulic plant of the Des Moines Edison Light Co., and the improvements recently made. 1500 w. Eng News—Nov. 17, 1904. No. 66129.

The Highest Fall in the World. Enrico Bignami. Illustrated description of the hydroelectric station in the Valais Canton, Switzerland, utilizing a head of 3,116 feet. 2800 w. Elec Rev, N. Y.—Oct. 29, 1904. No. 65867.

Isolated Plant.

The Power Plant of the "Glass Block," Minneapolis. Illustrates and describes a plant designed to supply heat, light, power and water to a large department store. 3000 w. Elec Rev, N. Y.—Nov. 26, 1904. No. 66340.

Manchester.

The Stalybridge, Hyde, Mossley, and Dukinfield Tramways and Electricity Board's Scheme. An illustrated article giving information of recent work in the development of this scheme in the neighborhood of Manchester, Eng. 3000 w. Elec Rev, Lond—Nov. 11, 1904. No. 66194 A.

Power Plants.

An Economical Power Plant at Lima, Ohio. Frank D. Rae. An illustrated description of a plant embracing the latest ideas of equipment in connection with reciprocating engines, and introducing a novel floor arrangement of apparatus. 5500 w. St Ry Jour—Nov. 26, 1904. No. 66370 C.

A Notable Electric Power Station. An illustrated article describing the plant of the St. Lawrence River Power Company at Massena, New York. 1800 w. Stevens Ind—Oct., 1904. No. 66402 D.

Power Plant of the Railway Exchange Building, Chicago. Illustrated description of a plant possessing some novel features necessitated by the somewhat unusual conditions under which it is operated. 2500 w. Engr, U S A—Nov. 15, 1904. No. 66059 C.

The Power Plant of the Lewis Publishing Company, St. Louis, and the Largest Searchlight in the World. Illustrates and describes a plant having many interesting features seldom encountered. 1500 w. Elec Wld & Engr—Nov. 12, 1904. No. 66033.

The Power Plant of the Tall Office Building. S. H. Bunnell. A comparison between compound and four-valve simple engines running non-condensing. 1500 w. Trans Am Soc of Mech Engrs, No. 045—Dec., 1904. No. 66074.

Storage Batteries.

Some Notes on the Edison Nickel-Iron Storage Battery. F. M. Davis. A report of tests made and the results of the investigation. General discussion. 12000 w. Jour W Soc of Engrs—Oct., 1904. No. 66098 D.

The Care of Storage Batteries. John Howatt. Gives suggestions for the proper care of a battery plant. 1400 w. Power—Nov., 1904. No. 65877 C.

Switchboards.

Modern High-Potential Switchboard Practice. Bertrand Perry Rowe. An illustrated description of modern switchboard practice, especially in connection with high-tension work. 2500 w. Elec Rev, N. Y.—Oct. 29, 1904. Serial. 1st part. No. 65866.

Switchboard Design. A. S. Loizeaux. Illustrates and describes some of the most distinct types, giving the purposes for which they are used; also their general layout and equipment. 2500 w. Stevens Ind—Oct., 1904. No. 66408 D.

Transformers.

The Graphic Treatment of the Phenomena of Static Transformers and Induction Motors. A. S. McAllister. An outline description presenting the facts upon which the construction of the circular dia-

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gram depends and giving a comprehensive example of its application to an induction motor treated as a transformer. 3000 w. Sib Jour of Engng—Nov., 1904. No. 66086 C.

Turbine Generator.

See Mechanical Engineering, Steam Engineering.

LIGHTING.

Decorations.

The Electrical Decorations of San Francisco. Illustrates and describes the more prominent illuminations, giving details of difficulties encountered and the means of overcoming them. 1500 w. Jour of Elec—Nov., 1904. Serial. 1st part. No. 65957 C.

Electric Signs.

"Signs of the Times." E. Leavenworth Elliott. Discusses the various uses of electric signs and the methods and principles involved in their construction. 2800 w. Cent Sta—Nov., 1904. No. 66014.

Nernst Lamp.

The Nernst Lamp as a Factor in Commercial Lighting. E. R. Roberts. Reviews the history of this form of electric lighting, its development in America, its efficiency, applications and progress. 4200 w. Cent Sta—Nov., 1904. No. 66015.

Theatres.

Electricity in Stage Lighting (Die Elektrizität im Bühnenwesen). Heinrich Rupprecht. Describing lamps, projectors and general systems of wiring in the use of electric lighting for theatres. Two articles. 4000 w. Elektrotech u Polytech Rundschau—Nov. 1, 15, 1904. No. 66281 each B.

MEASUREMENT.

Curves.

Graphic Tracings of the Faradic and Other Interrupted Currents. H. Lewis Jones. Gives results of examination of the characteristic curves of certain medical induction coils. 3400 w. Elec Rev, N. Y.—Nov. 26, 1904. No. 66342.

Electrode-Potential.

The Measurement of the Potential of the Electrodes in Stationery Liquids. Henry J. S. Sands. Read before the Faraday Society. Describes a method which will allow the electrode potential in stationary liquids of the most varying kind to be measured, when much larger currents are employed than those which can be made use of according to Cottrell's method, and indicates conclusions drawn. Ills. 3700 w. Elect'n, Lond—Oct. 28, 1904. Serial. 1st part. No. 65981 A.

Resistance Boxes.

Resistance Boxes for Use in Precise Alternating Current Measurements. George A. Campbell. Shows that a practically reactanceless coil may be produced by double-winding the coil as usual and then shunting the coil with a definite small condenser. 1700 w. Elec Wld & Engr—Oct. 29, 1904. No. 65871.

Voltmeters.

Alternating-Current Compensated Voltmeters. H. W. Young. Considers the more important types of a device by the use of which the pressure maintained at the point of distribution can readily be determined and the potential regulators properly adjusted to maintain the desired voltage. 2000 w. Am Elect'n—Nov., 1904. No. 65910.

Wattmeters.

The Care, Testing and Adjustment of Integrating Wattmeters. K. L. Aitken. Information of a general nature. 1700 w. Can Elec News—Nov., 1904. No. 66120.

MOTORS.

Alternating Motors.

The Theory of the Winter-Eichberg Motor (Zur Theorie des Winter-Eichberg-Motors). Paul Müller. A comparison of the Winter-Eichberg motor with the single-phase induction motor, deriving diagrams and formulas for the former. 6500 w. Elektrotech Zeitschr—Oct. 27, 1904. No. 66238 B.

Control.

Multiple-Voltage Control of Motors. Norman Gardner Meade. Gives an outline of the multiple-voltage system and the methods of control employed, and its application to machine tool operation. Ills. 2400 w. Power—Nov., 1904. No. 65875 C.

Design.

The Rational Design of Asynchronous Motors (Sur l'Etablissement Rationnel des Moteurs Asynchrones). C. F. Guilbert. Working out the mathematical computations for the proportions giving the maximum efficiency. 1500 w. Revue Technique—Oct. 25, 1904. No. 66220 D.

Diagrams.

The Alternating-Current Series Motor Considered as a Choking Coil (Der Wechselstrom-Serienmotor als Allgemeine Drosselspule). H. Weichsel. Study of the circle diagram, showing the identity of the diagrams of the alternating series motor and the ordinary choking coil. 2500 w. Elektrotech Zeitschr—Oct. 20, 1904. No. 66237 B.

Induction Motors.

The Induction Motor with High Resistance Secondary. C. J. Spencer. Defines certain cases where the installation of such a type of motor is desirable. 1100 w. Elec Wld & Engr—Nov. 26, 1904. No. 66375.

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Polyphase.

Some Polyphase Motors (Ausgeführte Drehstrommotoren). Jens Bache-Wiig. Describing motors of 250, 25, and 0.25 horse power, of simple construction and high efficiency. 2500 w. Zeitschr f Elektrotechnik—Nov. 6, 1904. No. 66247 D.

Repulsion Motor.

The Second Form of Repulsion Motor and the Compensated Series Motor (Die Zweite Form des Repulsionsmotors und des Kompensierten Reihenmotors). M. Latour. With diagrams showing the various modifications in the commutation. 1200 w. Elektrotech Zeitschr—Nov. 10, 1904. No. 66242 B.

Single Phase.

Paper on Single-Phase Railway Motors at the New York Electrical Society. Lecture by Prof. A. S. McAllister in abstract, with remarks by Frank J. Sprague. 3700 w. St Ry Jour—Nov. 12, 1904. No. 66024 C.

Railway Motors for Single-Phase Alternating Current. Dr. Hans Behn-Eschenburg. Illustrates and describes two of the later single-phase commutator types of motor made by the Oerlikon Company, criticizing their characteristics as deduced from experimental results. 2600 w. Engng—Nov. 4, 1904. No. 66052 A.

Single-Phase Commutator Motors. Seijiro Sugiyama. A theoretical treatment of series and repulsion motors. Mathematical. 700 w. Elec Wld & Engr—Oct. 20, 1904. Serial. 1st part. No. 65870.

See also Street and Electric Railways.

TRANSMISSION.

Austria-Hungary.

The Electrical Equipment of the Karawanken Tunnel. Illustrated description of an interesting power transmission plant and equipment in Austria-Hungary for transmitting power to be used in tunnel construction. 1300 w. Elec Wld & Engr—Nov. 12, 1904. No. 66032.

High Tension.

Some Operating Experiences in High-Tension Transmission. D. L. Huntington. Read before the Assn. of Edison Illuminating Cos. at Newcastle, N. H. An account of operating experiences with reference to unexpected problems, and methods of solving them, at Boston. 4000 w. Elec Rev, N. Y.—Oct. 29, 1904. No. 65869.

Long Distance.

Economics of a 200-Mile Transmission. J. Eugene Wallace. An explanation of rules and formulas resulting from a study of the methods of calculating voltages and line efficiencies, illustrating by an assumed enterprise. 1500 w. Elec Wld & Engr—Nov. 5, 1904. No. 65956.

Review.

Electrical Power-Generating Stations and Transmission. L. B. Stillwell. Read before the Int. Engng. Cong., St. Louis. A review of the changes that have occurred during the last ten years, the progress in transmission, &c. 7000 w. Elec Rev, N. Y.—Oct. 29, 1904. No. 65868.

Safety Appliance.

A Safety Appliance for High Tension Electric Conductors (Sur un Dispositif de Securité pour Canalisations Electriques à Haute Tension). L. Neu. Describing a safety switch arranged to cut off the current in case of defective insulation or accidental contact. 1000 w. Comptes Rendus—Oct. 31, 1904. No. 66233 D.

MISCELLANY.

Address.

Dr. Siemens' Presidential Address to the Institution of Electrical Engineers. Discusses the relations between capital and labor and the management of works. 6700 w. Elect'n Lond—Nov. 11, 1904. No. 66196 A.

INDUSTRIAL ECONOMY

Coal Mining.

The Coal Mine Operator versus the Public. Herman Justi. An address on "Coal Men's Day" at the Louisiana Purchase Exposition, St. Louis. Considers the peculiar conditions which have resulted in criticism of operators by the general public. 8000 w. Mines & Min—Nov., 1904. No. 65935 C.

Cost-Finding.

Economy in Foundry Cost-Finding. Jas. C. Loughry. Read at the A. F. A. Convention, June, 1904. A brief explanation of a ledger balance system and the results obtained, with remarks. 3400 w. Foundry—Nov., 1904. No. 65888.

Education.

Contemporary Technical Education. John R. Freeman. An address at the "Case School of Applied Science." Remarks on technical graduates and their opportunities, with notes of interest. 6000 w. Jour W Soc of Engrs—Oct., 1904. No. 66097 D.

Iron Industry.

Changes in the American Iron Industry

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Since the Iron and Steel Institute Meeting of 1890. B. E. V. Luty. Briefly reviews the more important changes that have occurred during fourteen years. 4500 w. Ir Trd Rev—Oct. 27, 1904. No. 65861.

Organization.

The Office Organization. W. R. Heath. A discussion of the principles upon which business is based. 5000 w. Cent Ry Club—Nov. 11, 1904. No. 66069 C.

Shipping.

The World's Ocean-Going Trade. Brysson Cunningham. An examination of the shipping statistics, with especial reference to British shipping and a comparison of other nations. Ill. 3000 w. Cassier's Mag—Nov., 1904. No. 66061 B.

Works Management.

System in Manufacturing Establishments. E. R. Douglas. An explanation of modern methods of maintaining economy in manufacturing works, the careful looking after details, &c. 7500 w. Stevens Ind—Oct., 1904. No. 66403 D.

MARINE AND NAVAL ENGINEERING

Battleships.

H. M. S. King Edward VII. Illustration, with brief description. 800 w. Engr, Lond—Nov. 4, 1904. No. 66055 A.

Steam Trials of H. M. S. "Dominion." Illustrations, description, and report of trials. 1400 w. Engng—Nov. 4, 1904. No. 66051 A.

The Sea-Going Battleship. Commander William Hovgaard. An attempt on basis of general principles, to arrive at the type and size of warship best suited to secure command of the ocean. Ills. 11000 w. Soc Naval Archts & Marine Engrs, No. 3—Nov., 1904. No. 66137 D.

Boilers.

See Mechanical Engineering, Steam Engineering.

Capstan.

Improved Electric Capstan (Nouveau Système de Cabestan Electrique). F. Loppé. Describing the electric capstan made by the Creil Works; so arranged that it can be inverted upon trunnions to give access to the electric machinery. 1800 w. Revue Technique—Oct. 25, 1904. No. 66219 D.

Coaling.

Coaling Warships at Sea—Recent Developments. Spencer Miller. An illustrated article reviewing the development from 1900 to the present time. 9500 w. Soc of Naval Archts & Marine Engrs, No. 7—Nov., 1904. No. 66141 D.

Coast Defense.

The Semi-Globular Naval Battery. Anson Phleps Stokes. An illustrated explanation of the designs for a vessel invented by the writer. It is considered an impregnable coast defense ship, and a powerful battleship. 4800 w. Soc of Naval Archts & Marine Engrs, No. 2—Nov., 1904. No. 66136 D.

Cruisers.

H. M. Armored Cruiser Black Prince. Detailed description. 1800 w. Engr, Lond—Nov. 11, 1904. No. 66304 A.

The Japanese Cruisers Nisshin and Kasuga. Illustrations, with description. 1500 w. Engr, Lond—Nov. 4, 1904. No. 66057 A.

The U. S. Armored Cruiser Colorado. J. M. Powell. An illustrated description of this vessel and its performance. 5500 w. Soc of Naval Archts & Marine Engrs, No. 17—Nov., 1904. No. 66151 D.

Cylinders.

The Breakage and Renewal of a Large Cylinder. Hector MacColl. An account of a cylinder broken at sea, the work of renewal, and the lessons learned from the occurrence. Plate. 1200 w. Trans Inst of Engrs & Shipbuilders of Scotland—Oct. 25, 1904. No. 66412 D.

Dry Docks.

See Civil Engineering, Waterways and Harbors.

Ferryboats.

Ferry Transportation. Capt. J. M. Cherry. An illustrated review of the old and the modern methods of handling passengers in and around New York. Also gives briefly an account of the ferry service at San Francisco. Discussion. 16000 w. Pro N Y R R Club—Oct. 21, 1904. No. 66107.

Fuel Endurance.

Speed and Consumption of Steamships. J. F. Ruthven. Suggestions on the importance of understanding how to vary the speed so as to get the best value out of the coal. 3000 w. Jour Roy United Serv Inst—Oct., 1904. No. 65887 E.

Great Britain.

Naval Architecture. Sir William H. White. Read before the Int. Engng. Cong. at St. Louis. Indicates the principal advances made in methods of ship construction and propulsion during the last ten years in Great Britain. 6000 w. Marine

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Engng—Nov., 1904. Serial. 1st part. No. 65853 C.

Launching.

Recent Launching Practice of the Atlantic Coast. R. H. M. Robinson. Gives launching data, with description of special features in the methods used on the Connecticut, recently launched. 1400 w. Soc of Naval Archts & Marine Engrs, No. 14—Nov., 1904. No. 66148 D.

Recent Launching Practice of the Pacific Coast. Everett P. Lesley. Illustrates and describes features of interest in the recent launching of the U. S. S. California, South Dakota, and Milwaukee. 1700 w. Soc of Naval Archts & Marine Engrs, No. 15—Nov., 1904. No. 66149 D.

Machinery.

Maintenance of Machinery in Merchant Ships. Robert Haig. Discusses this subject, considering the various changes, improvements and developments that experience gained in maintenance has brought about. 12000 w. Soc of Naval Archts & Marine Engrs, No. 11—Nov., 1904. No. 66145 D.

Marine Engines.

Marine Engine Models at South Kensington. Brief descriptions of interesting models on exhibition in England. 2400 w. Engr, Lond—Nov. 18, 1904. No. 66394 A.

Motor Boats.

High Speed Gasoline Launches. Clinton H. Crane. Illustrated description of the performance of the Vingt-et un II, and information of general interest. 1700 w. Soc of Naval Archts & Marine Engrs, No. 12—Nov., 1904. No. 66146 D.

Speed and Power of Recent Motor Boats of Several Types. Alpheus A. Packard. Illustrates and describes various types of boats, giving actual results as to speed and power. 2500 w. Soc of Naval Archts & Marine Engrs, No. 13—Nov., 1904. No. 66147 D.

Navigation.

A Geometric Solution of the Problem of Great-Circle Sailing (Soluzione Geometrica del Problema della Navigazione per Cerchio Massimo). Prof. Luigi Masnata. Developing graphical methods for determining a number of points on the arc of a great circle. 5000 w. Rivista Marittima—Oct., 1904. No. 66252 H.

Paddle Steamer.

Paddle Steamer for the Anatolian Railway Company of Constantinople (Passagier-Raddampfer für die Anatolische Eisenbahn-Gesellschaft in Konstantinopel). Description and illustrations of the passenger steamer Basra built at the Howaldts Works at Kiel. 1800 w. Schiffbau—Nov. 9, 1904. No. 66273 D.

Progress.

Developments in Means of Communication by Sea During the Nineteenth Century. Dr. Robert-Caird's lecture under the auspices of the Royal Philosophical Society of Glasgow. A review of the period from 1802 till 1902. 3500 w. Sci Am Sup—Nov. 19, 1904. Serial. 1st part. No. 66117.

Propellers.

Tests of Various Types of Propellers (Proeven met Schroeven van Verschillend Type). Murk Lels, Jr. With curves plotted from tests of screw propellers with blades bent back at various angles. 1200 w. De Ingenieur—Sept. 17, 1904. No. 66275 D.

Propulsion.

Triple Screw Propulsion. Rear-Admiral George W. Melville. Gives reasons in favor of the three-screw system, and also some of the disadvantages that might arise. 3600 w. Marine Engng—Nov., 1904. No. 65851 C.

Repairs.

Interesting Repair Work on the Steamship "Ekliptika." Dr. Alfred Gradenwitz. An illustrated article describing the raising and repairing of a vessel wrecked on the Swedish coast. 800 w. Sci Am Sup—Nov. 26, 1904. No. 66309.

The Repairing of the Steamship Ekliptika (Die Reparatur des Dampfers Ekliptika). An account of the raising and docking of a vessel after being submerged for more than a year off the coast of Sweden. 1000 w. Schiffbau—Sept. 14, 1904. No. 66267 D.

Report.

Steam Engineering in the Navy. Advance abstract of the annual report of Chief Engineer Rae, outlining important plans for experimental work of interest to engineers and builders of ships and engines. 1000 w. Ir Age—Nov. 17, 1904. No. 66109.

Resistance.

The Theory of Froude's Constant for the Determination of Ship's Resistance (Beitrag zur Theorie der Konstanten Froude's zur Bestimmung des Schiffswiderstandes). A mathematical examination of the derivation of Froude's Constant. 1800 w. Schiffbau—Oct. 26, 1904. No. 66272 D.

Sanitarium.

A Design for a Floating Sanitarium (Entwurf zu einem Schiffssanatorium). Oswald Flamm. Complete designs for a ship intended to serve as a sanitarium at sea for such patients as would be benefitted by sea air. 2000 w. 3 plates. Schiffbau—Oct. 12, 1904. No. 66269 D.

We supply copies of these articles. See page 719.

Special Machinery.

Special Machinery and Appliances on Board Ship. George McQuilkin, Jr. Shows the important bearing electrical installations have had on the development of special machinery. 2400 w. Marine Rev—Nov. 3, 1904. No. 65959.

Special Machinery on Board a Naval Ship. Perry K. Thurston. Describes some of the conveniences and labor-saving devices used on the modern naval vessel. 2800 w. Marine Rev—Nov. 3, 1904. No. 65960.

Stability.

A New Interpretation of Experiments upon the Stability of Ships (Sopra una Nuova Interpretazione della Esperienza di Stabilita delle Navi). A. Scribanti. Deriving new equations for the curve of stability for use with experimental data. 6000 w. Rivista Marittima—Aug.-Sept., 1904. No. 66251 H.

On the Determination of the Vertical Position of the Center of Gravity of a Ship by Means of a Dock Trial. Translated from *Schiffbau*. Describes a purely theoretical method, not yet put in practice. 1200 w. Prac Engr—Nov. 11, 1904. No. 66191 A.

The Determination of the Position of the Centre of Gravity by Dock Trials (Bestimmung der Höhenlage des Systemsschwerpunktes durch einen Dockversuch). Alexander Dietzius. The height of the centre of gravity is determined by observing the depth of water in the dock at the moment when the stability becomes zero. 1200 w. Schiffbau—Sept. 28, 1904. No. 66268 D.

The Position of the Center of Lateral Resistance. L. E. Bertin. Considers the point of application of all the forces tending to resist the lateral motion of a vessel, discussing its experimental determination. 800 w. Soc of Naval Archts & Marine Engrs, No. 5—Nov., 1904. No. 66139 D.

Steamships.

Mammoth Steamship Dakota. Large illustration with description of this vessel, its equipment and pumping machinery. 4000 w. Am Shipbuilder—Nov. 24, 1904. No. 66391.

Steam Turbines.

The Economy of Steam Turbines in Cruisers. Ediorial on the trials of H. M. S. Amethyst, which demonstrated the economy of the Parsons steam-turbine. 4000 w. Engng—Nov. 18, 1904. No. 66389 A.

Submarines.

The Evolution of the Submarine and How Far the Lake Type Solves the Problem. Robert G. Skerrett. Discusses types, and methods of submergence, and reviews the development of the Lake type. Ills. 10900 w. Jour U S Art—Sept., 1904. No. 65903 D.

Tank Trials.

Some Recent Experiments at the U. S. Model Basin. D. W. Taylor. An account of experiments, the primary object being the determination of the power and efficiency of model propellers of the ordinary three-bladed type throughout the range of pitch ratio and blade area likely to be encountered in practice. Ills. and diagrams. 4500 w. Soc of Naval Archts & Marine Engrs, No. 6—Nov., 1904. No. 66140 D.

Torpedo Vessels.

Some Further Notes on the Performance of the Torpedo Vessels of the United States Navy at Sea. Lieut. L. H. Chandler. Tabulated information, illustrations and remarks of interest. 6000 w. Soc Nav Archts & Marine Engrs, No. 4—Nov., 1904. No. 66138 D.

Turbine Propulsion.

Design for a Light Draught Double Turbine Boat (Entwurf eines Flachgehenden Zwei-Turbinenschrauben-Bootes). O. Lienau. Plans and details of a flat-bottomed light-draught steamboat with turbine propellers, for river inspection service. Two articles. 4000 w. Schiffbau—Oct. 26, Nov. 9, 1904. No. 66271 each D.

Ventilation.

Some Experiments with Ventilating Fans. D. W. Taylor. An account of experiments made for supplying fresh air to vessels, to determine the fan that will supply the required quantity of air with the least expenditure of power. 4500 w. Eng News—Nov. 3, 1904. No. 65922.

Warships.

Simple Methods in Warship Design a Necessity. George W. Dickie. A discussion of the importance of this subject, presenting plans showing the application of methods proposed to secure the results aimed at in a modern armored cruiser. 11200 w. Soc of Naval Archts & Marine Engrs, No. 1—Nov., 1904. No. 66135 D.

Warships of the Great Powers. Archibald S. Hurd. A study of relative costs. 5800 w. Cassier's Mag—Nov., 1904. No. 66064 B.

Weights.

Subdivision of Weights in Ships' Displacement. Nabor Soliani. Aims to induce some step to be taken toward the avoidance of the vagueness in relation to the distribution of the weights of various parts of a vessel. 4500 w. Soc of Naval Archts & Marine Engrs, No. 10—Nov., 1904. No. 66144 D.

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MECHANICAL ENGINEERING

AUTOMOBILES.

Darracq.

The 15-H. P. Darracq. Illustrated description of the latest pattern Darracq car. 1200 w. Autocar—Nov. 5, 1904. No. 66042 A.

De Dion.

The 15-H. P. 4-Cylinder De Dion Car. An illustrated detailed description of a new model. 1100 w. Auto Jour—Nov. 12, 1904. Serial. 1st part. No. 66186 A.

Electric Transmission.

Electric Transmission Devices for Automobiles: the Jeantaud and the Electrogenia Systems. Illustrates and describes two new devices recently brought out in Paris. 1500 w. Sci Am Sup—Nov. 26, 1904. No. 66311.

Gasoline.

Adams-Farwell Car with Rotating Motor. Illustrates and describes details of interest in a new gasoline automobile. 1100 w. Automobile—Oct. 29, 1904. No. 65850.

Hotchkiss.

The Hotchkiss Cars. Illustrates and describes interesting details of these cars. 1800 w. Autocar—Oct. 29, 1904. No. 65973 A.

Hutton.

The Hutton 4-Cylinder Light Car. Illustrated description. 2500 w. Auto Jour—Nov. 5, 1904. No. 66041 A.

Igniter.

The Bullock Igniter. Description and diagrams showing the method of employing the electric current for the ignition of the compressed charges of carburetted air within the cylinders of explosion motors. 900 w. Autocar—Nov. 12, 1904. No. 66189 A.

Motor Mail.

A Night with the Royal Motor Mail. R. G. Wells. An illustrated account of the Manchester-Liverpool motor mail service. 1500 w. Autocar—Nov. 12, 1904. No. 66188 A.

"Rational."

The 10-H. P. "Rational" Petrol Car. Begins an illustrated detailed description of this car. 1200 w. Auto Jour—Nov. 19, 1904. Serial. 1st part. No. 66352 A.

Seabury.

Seabury 24-H. P. Gasoline Automobile. Describes a touring-car being built at the Morris Heights shops. 2200 w. Automobile—Nov. 26, 1904. No. 66336.

Speed Records.

Recent Automobile and Motor-Boat Speed Records. A review of the speeds attained during the last racing season. Ills. 1200 w. Sci Am—Nov. 19, 1904. No. 66113.

Storage Batteries.

See Electrical Engineering, Generating Stations.

Timing.

A Mors Electric Device for Timing Automobiles. B. F. Hirshaur. Illustrated description of a new electric chronometer. 2200 w. Elec Rev, N. Y.—Nov. 26, 1904. No. 66341.

Vauxhall.

The Three-cylinder Vauxhall Car. Begins an illustrated detailed description of this new car. 1500 w. Autocar—Nov. 12, 1904. Serial. 1st part. No. 66187 A.

Winton.

The Winton Petrol Cars. An illustrated description of the leading characteristics of the 20 h. p. model. 2000 w. Auto Jour—Oct. 29, 1904. Serial. 1st part. No. 65972 A.

HEATING AND COOLING.

Freezing.

The Danger of Freezing in Hot-Water and Low-Pressure Heating Systems (Die Einfriergefahr bei Niederdruckdampf- und Warmwasserheizung). W. Schweer. Describing precautions to be taken to prevent injury to pipes and radiators in cold weather. 2500 w. Gesundheits-Ingenieur—Oct. 31, 1904. No. 66264 B.

Hospital.

The Heating System of the Johannstadt Hospital, Dresden-Altstadt (Die Heizanlagen im Krankenhaus Johannstadt, Dresden-Altstadt). Erwin Nicolaus. Describing a central heating plant using hot water for a large hospital in Dresden. 4000 w. 2 plates. Gesundheits-Ingenieur—Oct. 10, 1904. No. 66263 B.

Kryptol.

Kryptol, a New Substance for Electric Heating. Information concerning an indirect electrical heating system recently invented in Germany. Ills. 1200 w. U S Cons Repts—Oct., 1904. No. 66369 D.

Ventilation.

Ventilation. W. Henman. Read before the Archt. Assn., England. Paper and discussion on modern practice in ventilating buildings. 11600 w. Builder—Nov. 19, 1904. No. 66350 A.

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HYDRAULICS.

Air-Lift.

An Ingenious and Effective Air-Lift Pump. Illustration, with description, of pump invented by D. W. Starrett. 1500 w. Eng News—Nov. 24, 1904. No. 66335.

Hydraulic Rams.

Note on Action of Hydraulic Rams. A. J. Wood. Gives diagrams obtained in a test, typical for the pressure shown, with explanation of the action. 500 w. Stevens Ind—Oct., 1904. No. 66405 D.

Hydraulic Tools.

Hydraulic Punching and Shearing Machinery (Lochstanze und Blechschere mit Druckwasserbetrieb). A. Heller. Illustrating tools operated by water at a pressure 120 to 150 atmospheres, and used for punching plates up to 35 mm. thick. 1200 w. Zeitschr d Ver Deutscher Ing—Nov. 5, 1904. No. 66209 D.

Hydroelectric Stations.

See Elecerical Engineering, Generating Stations.

Jet Pump.

The Jet Pump as an Hydraulic Apparatus. F. G. Hesse. Considers the jet pump as an hydraulic apparatus in which the jet and the liquid to be raised are both non-compressible and of the same density. 1000 w. Jour Assn of Engng Socs—Sept., 1904. No. 66171 C.

Plumbing.

Modern Plumbing. R. M. Starbuck. A practical review of the requirements of good plumbing. Ills. 2000 w. Archts & Bldrs Mag—Nov., 1904. Serial. 1st part. No. 65953 C.

Presses.

British Hydraulic Machinery. A. F. Petch. An illustrated account of various special hydraulic presses used in the manufacture of munitions of war. 3000 w. Cassier's Mag—Nov., 1904. No. 66062 B.

Design of a 4,000-Ton Hydraulic Press. W. E. Morey. Illustrates and describes the designing of a press to meet stated requirements. 1600 w. Am Mach—Nov. 17. 1904. Serial. 1st part. No. 66111.

Hydraulic Forging Presses. Illustrates and describes a new 3,000-ton hydraulic press. 2200 w. Engng—Nov. 11, 1904. No. 66198 A.

Pumping Plant.

Pumping Plant at Chatham Dock-Yard. Illustrates and describes two sets of high-duty pumping engines and their operation. 600 w. Engr, Lond—Nov. 18, 1904. No. 66396 A.

The Pumping Plant of the Utrecht Water Works (De Pompwerktuigen van de Utrechtsche Waterleiding). J. C. Dijxhoorn. Details of the performance of simple and compound engines, by Carels, of Ghent, and Sulzer, of Winterthur, with steam and water indicator diagrams. 3000 w. De Ingenieur—Sept. 17, 1904. No. 66276 D.

Pumps.

Pumps in Central Stations. W. T. Edwards. Discusses the importance of the pump as a factor in the economical operation of a power plant. 2200 w. Am Elect'n—Nov., 1904. No. 65912.

Standpipes.

A New Hydraulic Experiment. A. F. Nagle. Experimental investigation of the rise of water in a standpipe having a long supply pipe, when the draft suddenly ceases. Ills. 1200 w. Trans Am Soc of Mech Engrs, No. 050—Dec., 1904. No. 66103.

Steam Pumps.

Tables for Computing Compound Duplex Steam Pumps. C. J. Mitchell. Gives tables useful in determining the principal proportions of these pumps, illustrating the method of using them. 1500 w. Eng News—Nov. 17, 1904. No. 66128.

The Time Required to Raise Steam for Fire Pumps from Cold Boilers and the Cost of Banked Fires. Gives conclusions drawn from tests made by inspectors of the Associated Factory Mutual Fire Insurance Co., at Fall River, Mass., to determine whether it would be safe for the mills to allow the fire to be drawn from their fire-pump boilers during a shutdown. 1500 w. Eng News—Nov. 3, 1904. No. 65924.

Turbine Pumps.

Turbine Pumps in Irrigation. J. J. Brown. From an address before the Nat. Ir. Cong. at El Paso, Tex. General remarks on land developed by the pumping system, especially discussing the advantages of the centrifugal pump. 3300 w. Mfrs Rec—Nov. 24, 1904. No. 66312.

Water Power.

Some Details Entering into the Computation of the Values of Water Powers, and the Damages Caused by the Diversion of Water Used for Power. Charles T. Main. Considers the methods of determining the value, and the damages, the flow. &c. 6500 w. Trans Am Soc of Mech Engrs, No. 025—Dec., 1904. No. 66076 C.

Water-Wheels.

The Governing of Impulse Water-Wheels. John Goodman. Deals chiefly with impulse water-wheels in which the whole energy of the water is converted into kitetic energy before it impinges on the vanes of the motor; such motors are

tangent wheels, Pelton wheels, action or impulse turbines. 1700 w. Engng—Nov. 4, 1904. No. 66050 A.

INTERNAL-COMBUSTION MOTORS.

Combustion Chamber.

Experiments with a Chamber for the Production of a Hot Working Fluid to be Used in the Generation of Power. J. F. Wentworth. Describes investigations extending through six months on a working fluid for internal combustion engines. 3000 w. Power—Nov., 1904. No. 65878 C.

Diesel.

The Diesel Engine. A. W. Oppenheimer. Describes and illustrates the Diesel engine, explaining the principles upon which it is based, its operation, &c. 3300 w. Sci Am Sup—Nov. 5, 1904. No. 65927.

The Diesel Engine in Practice. James D. Macpherson. Describes this form of internal combustion engine as used in America; the operation, types, regulation, &c. Discussion. 2700 w. Pro Engrs' Club of Phila—Oct., 1904. No. 66068 D.

Gas Engines.

Gas Engine Power Plants. Irving A. Chandler. Presents the qualifications which make the gas engine power plant particularly suitable for mining purposes. Ills. 2500 w. Min Mag—Oct., 1904. No. 66085 C.

Gas Engine Testing at the Works of the Westinghouse Machine Co. A brief explanation of the gas engine tests as made at these shops. 900 w. Eng Rec—Nov. 19, 1904. No. 66156.

Gasoline Motor.

The Adams Farwell Gasoline Motor. Illustrated description of an engine designed for automobile use in which the engine shaft remains stationary and the cylinders revolve around it. 2400 w. Ir Age—Nov. 3, 1904. No. 65906.

Gas Turbines.

A Scientific Investigation into the Possibilities of Gas Turbines. R. M. Neilson. Compares the advantages and possibilities of gas turbines worked on different cycles, and the difficulties to be overcome to make these turbines a success. 12700 w. Inst of Mech Engrs—Oct. 21, 1904. No. 65885 D.

Heat Engines.

A Proposed Modification of the Perfect Heat-Engine Formula. Louis Illmer, Jr. Suggestions regarding the improvement of the isolation factor indicating the lines along which increase in the economy of internal combustion motors is to be sought. 6000 w. Jour Fr Inst—Nov., 1904. No. 66093 D.

Heat Wastes.

Some Forms of Vapor Heat Maps with Vapor Table and Curves for Ether ($C_4H_{10}O$). Thomas M. Gardner. A discussion of the conditions under which the vapor of ether may be used in binary-vapor engines. 2500 w. Sib Jour of Engng—Nov., 1904. No. 66088 C.

Power Gas.

Power Gas (Kraftgas). Ferd. Fischer. A comparison of the various forms of fuel gas and their monetary values for the production of power. 3000 w. Zeitschr d Ver Deutscher Ing—Oct. 29, 1904. No. 66207 D.

MACHINE WORKS AND FOUNDRIES.

Boring.

A Worm Driven Auxiliary Table for a 16 by 24 Niles Boring Mill. H. G. Knoderer. Describes and illustrates the method used in the Westinghouse shops of extending a boring mill for large work. 700 w. Am Mach—Vol. 27, No. 45. No. 65993.

Boring Machine.

Boring Machine for Steam-Turbine Casings (Barrow's Patent) at Clydebank Shipyard. Illustrated description. 400 w. Engng—Nov. 11, 1904. No. 66301 A.

Castings.

On Small Plants for the Production of Castings. R. M. Daelen. Considers the working of small Bessemer plants, small open-hearth furnace, and the application of the electric current. 1500 w. Ir & Coal Trds Rev—Nov. 4, 1904. No. 66045 A.

Designing.

Things That Are Usually Wrong. John E. Sweet. The first of a series of articles commenting on faults overlooked by designers in making new machines or improving old ones. Ills. 700 w. Am Mach—Vol. 27, No. 45. No. 65994.

Dynamo Works.

The Lancashire Dynamo and Motor Company's Works. An illustrated detailed description of these shops and their development, and some of their products. 3500 w. Engr, Lond—Nov. 18, 1904. No. 66395 A.

Electric Driving.

Discussion on the Individual Operation of Machine Tools by Electric Motors. Discussion, with opening remarks by Charles Day. Ills. 9500 w. Jour Fr Inst—Nov., 1904. No. 66092 D.

The Electrical Equipment of a Modern Type Foundry. Illustrated description of the plant of the American Type Founders' Company, at Communipaw, N. J. 3300 w. Am Elect'n—Nov., 1904. No. 65908.

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Fits.

Fits in Machine Construction (Die Passungen im Maschinenbau). Dr. G. Schlesinger. A discussion of the proper allowances to be made for running, driving, and forcing fits in machine work, with results of experiments. 3000 w. Zeitschr d Ver Deutscher Ing—Oct. 22, 1904. No. 66203 D.

Foundry.

An Up-to-Date Foundry and Electrical Plant. William D. Ranney and Robert N. Hemming. Brief illustrated description of the plant of the Buckeye Steel Casting Co. 1600 w. Engr, U S A—Nov. 1, 1904. No. 65890 C.

Foundry Practice.

Chemistry in the Foundry. Dr. R. Moldenke. Read before the New England Found. Assn. A discussion of this subject and the benefits derived, urging a careful study of the standard specifications for foundry pig iron. 2300 w. Ir Trd Rev—Nov. 17, 1904. No. 66122.

Foundry Practice with Copper and Its Alloys. W. J. Reardon. Read before the Electric Club. Describes the requirements, and the practice of making such castings at the Westinghouse foundry. 1200 w. Mech Engr—Oct. 29, 1904. No. 65975 A.

Lathes.

High-Speed Lathes. P. V. Vernon. An illustrated discussion of high-speed headstocks. 14300 w. Engr, Lond—Nov. 4, 1904. Supplement. No. 66058 A.

Machine Tools.

Machine Tools at the Parkhead Works. Illustrations, with brief descriptions, of three powerful machine tools recently installed in these Glasgow works. 1000 w. Engng—Nov. 18, 1904. No. 66386 A.

Milling.

Milling Cutters. Thomas R. Shaw. Illustrations, with descriptions, of various types of cutters. 3000 w. Mech Engr—Nov. 12, 1904. Serial. 1st part. No. 66192 A.

Molding.

Machine Molding a Special Gear—Fitting the Pattern. W. O. Smythe. Illustrates and describes the work. 2000 w. Am Mach—Vol. 27, No. 47. No. 66324.

Molding a Compound Gear on a Stripping Plate Machine. Illustrates and describes this method of molding. 2000 w. Am Mach—Vol. 27, No. 44. No. 65914.

Molding a Flywheel with Wrought-Iron Spokes. R. H. Palmer. Illustrates and describes the methods used in making a casting about 8 feet in diameter, weighing 5,000 pounds. 1000 w. Am Mach—Vol. 27, No. 45. No. 65992.

Molding Sheaves. Joseph Horner. Illustrated description of the method adopted. 1200 w. Am Mach—Vol. 27, No. 26. No. 66112.

The Molding of Double-Arm Pulleys (Das Formen einer Riemenscheibe mit Doppelten Armen). W. Emrich. Describing two methods of sweeping the rim and molding the arms. 1800 w. Stahl u Eisen—Oct. 15, 1904. No. 66255 D.

Sands.

Local Sands for Foundry Use. Walter J. May. Remarks on sands fit for foundry use, and their preparation. 900 w. Prac Engr—Nov. 11, 1904. No. 66190 A.

Shops.

Notes from the Jones & Lamson Shops. Brief illustrated descriptions of tools and methods used. 1800 w. Am Mach—Vol. 27, No. 47. No. 66323.

Tools.

Diamond Tools. G. C. Henning. A short illustrated description of these tools, used for cutting hard rubber, paper and hardened steel and also hard stone. 1400 w. Trans Am Soc of Mech Engrs, No. 052—Dec., 1904. No. 66101.

Tool System.

Systematization and Tool-Room Practice in a Railway Repair Shop. R. Emerson. The first paper discusses the extent to which standardization may be advantageously carried in a repair shop; together with the general organization of a tool management system. 3000 w. Engineering Magazine—Dec., 1904. No. 66288 B.

Tube-Mill.

The Operation of a Tube-Mlil. Hermann Fischer. Abstract from the *Zeitschrift des Vereines Deutscher Ingenieure*. Illustrated description of the operation of grinding. 2000 w. Eng & Min Jour—Nov. 17, 1904. No. 66126.

MATERIALS OF CONSTRUCTION.

Carborundum.

Carborundum. Dr. J. Ohly. Reviews the experiments of E. G. Acheson and the development of this substance, its uses, value, &c. 2000 w. Min Rept—Oct. 27, 1904. No. 65857.

Cast Iron.

Chemistry of Cast Iron. Herbert E. Field. Read before the New England Found. Assn. Discusses the composition and characteristics which make cast iron so valuable a product, the causes of the reactions, &c. 3000 w. Ir Trd Rev—Nov. 17, 1904. No. 66121.

Hardening.

The Le Chatelier Experiments on Hardening (Le Chatelier's Härteversuche). H. Haedicke. An account of the

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use of the Le Chatelier pyrometer for the measurement of temperatures during hardening processes. 2500 w. Stahl u Eisen—Nov. 1, 1904. No. 66258 D.

Hardness.

Indentation Tests on Steel. Illustrates and describes M. Guillery's apparatus and the method of making the tests. 1600 w. Engr, Lond—Oct. 28, 1904. No. 65985 A.

Impact Tests.

Impact Tests on the Wrought Steels of Commerce. A. E. Seaton and A. Jude. Aims to show some of the characteristics and peculiarities of wrought steel, to develop a more rational method of testing, and to point out peculiarities in the fracture of test specimens and actual pieces of machinery. 10 plates. 9300 w. Inst of Mech Engrs—Nov. 18 1904. No. 66392 D.

Metallography.

The Metallographic Department Technical School at Aix-la-Chapelle (Die Metallographische Einrichtung des Eisenhüttenmännischen Instituts in Aachen). A. Schüller. With illustrations of the micro-photographic apparatus, and a description of the methods of work. 2000 w. Stahl u Eisen—Oct. 15, 1904. No. 66253 D.

Solders.

Tests Made on Solders for Steel Brazing. Describes the tests and gives the results. 700 w. Engng—Oct. 28, 1904. No. 65983 A.

Steel.

The Transformation Temperatures of Steels (Sur les Températures de Transformation des Aciers). MM. G. Charpy and L. Grenet. Tabulated results of the determination of the temperatures by the measurement of the expansion, comparing these with the results of the thermo-electric method. 600 w. Comptes Rendus—Oct. 10, 1904. No. 66231 D.

Testing Machine.

A Universal 300-Ton Testing Machine. Illustrates and describes a machine in which the strength of full-sized members of structures may be tested. 1200 w. Sci Am Sup—Nov. 19, 1904. No. 66114.

MEASUREMENT.

Centrifugal Force.

The Bursting of Four-Foot Fly-Wheels. Charles H. Benjamin. An illustrated account of experimental investigations. 2200 w. Trans Am Soc of Mech Engrs, No. 017—Dec., 1904. No. 66079.

Dynamometer.

A Twist Drill Dynamometer. William W. Bird and Howard P. Fairchild. Illustrated description of a machine for measuring the twist or moment and the thrust of the drill, with some data acquired. 800 w. Trans Am Soc of Mech Engrs, No. 051—Dec., 1904. No. 66102.

Errors.

The Mechanical Principle of the Mean Error as a Measure of Precision (Die Mechanische Begründung des Mittleren Fehlers als Genauigkeitsmass). S. Wellisch. An examination of the analogy between the principle of least squares and the vibration of elastic bodies. 1800 w. Zeitschr d Oesterr Ing u Arch Ver—Nov. 4, 1904. No. 66224 D.

Fans.

Centrifugal Fans. August J. Bowie, Jr. Describes an apparatus designed by the writer to obtain a suitable velocity gauge for air which would be independent of any existing state of pressure. 2200 w. Trans Am Soc of Mech Engrs, No. 019—Dec., 1904. No. 66078.

Speeds.

Speed Indicators. Prof. Clarence P. Feldmann. General remarks on these devices and their defects, with illustrated description of the present form of the indicator invented by Hermann Frahm. 2500 w. Elec Wld & Engr—Nov. 19, 1904. No. 66184.

The Frahm Speed-Measuring Device (Frahm's Geschwindigkeitsmesser). Friedrich Lux. The vibrations set up in the mass of the observed body are determined by a selective series of vibrating springs. 1800 w. Zeitschr d Ver Deutscher Ing—Oct. 15, 1904. No. 66201 D.

Steam Meter.

An Indicating Steam Meter. C. E. Sargent. Describes a device designed by the writer, which is believed to overcome many of the difficulties which have hitherto been obstacles to success. Ill. 2500 w. Trans Am Soc of Mech Engrs, No. 028—Dec., 1904. No. 66075.

POWER AND TRANSMISSION.

Compressed Air.

A Study of Air Compressor Valves. Arthur P. Hall. An account of a recent series of tests made to study the action of these valves and the usual velocity of the air through them. Ills. 2400 w. Compressed Air—Nov., 1904. No. 66308.

Causes of Explosions in Air Compressors. Abstract of a paper by E. Goffe, and discussion, before the Mech. Engrs.' Assn. of the Witwatersrand, dealing with this subject. 1800 w. Engr, Lond—Nov. 11, 1904. No. 66305 A.

Compressed Air at the Louisiana Purchase Exposition. A review of the field of compressed air at the Exposition, showing the diversity of applications.

We supply copies of these articles. See page 719.

3500 w. Compressed Air—Nov., 1904. No. 66307.

The Application of Compressed Air to the Driving of Machine Tools (Verwendung von Pressluft Zum Antreib von Werkzeugmaschinen). Hr. Leiber. Discussing the comparative advantages of compressed, direct steam driving, belting, and electricity for driving machine tools. 5000 w. Zeitschr d Ver Deutscher Ing—Nov. 5, 1904. No. 66210 D.

Conveyors.

The Bleichert Electric Overhead Conveyor System (Das Bleichertsche Elektrohängebahn System). G. Dieterich. Illustrating and describing a system with fixed supporting rail and independently driven motor carriers using overhead roller contact trolleys. 3000 w. Elektrotech Zeitschr—Nov. 10, 1904. No. 66243 B.

Elevators.

Relative Efficiencies of Electric and Hydraulic Elevators. William C. L. Eglin. Abstract of a paper read at the Assn. of the Edison Ill. Cos. Remarks on the types of hydraulic and electric elevators, with an attempt to compare their mechanical efficiencies and the conclusions. 2000 w. Elec Rev, N Y—Nov. 12, 1904. No. 66036.

Power Plants.

See Electrical Engineering, Generating Stations.

Ropes.

Rope Transmission of Power. Frederick S. Greene. States briefly the most important advantages of rope transmission, and notes the growing use. Ills. 1500 w. Min Rept—Oct. 27, 1904. Serial. 1st part. No. 65856.

STEAM ENGINEERING.

Boiler Efficiency.

More Exact Methods for Determining the Efficiency of Steam Generating Apparatus. A. Bement. The author's views on the best method of determining the efficiency of boilers and the performance of steam generating apparatus. 2500 w. Trans Am Soc of Mech Engrs. No. 053—Dec., 1904. No. 66071.

Boilers.

A Voyage with Belleville Boilers. Editorial on a voyage recently made by the first-class cruiser Terrible, from England to Wei-hai-Wei, and back, showing the economy and steady working of the Belleville boilers. 1500 w. Engng—Nov. 18, 1904. No. 66387 A.

Staybolts, Braces and Flat Surfaces. R. S. Hale. A discussion of various rules and formulæ bearing upon the support of the flat surfaces of boilers. 3300 w. Trans Am Soc of Mech Engrs, No. 049—Dec., 1904. No. 66072.

Experiment and Practice in the Construction of Steam Boilers. Egbert P. Watson. A practical dissertation upon boiler design, discussing numerous sources of misunderstanding between maker and buyer. 3500 w. Engineering Magazine—Dec., 1904. No. 66287 B.

The Forcing Capacity of Fire Tube Boilers. F. W. Dean. Gives particulars of boiler tests upon different types of fire tube boilers, showing that the impression that these boilers have less capacity to be worked above the rated power than water-tubes, is incorrect. 2000 w. Trans Am Soc of Mech Engrs, No. 048—Dec., 1904. No. 66104.

The Schulz Water-Tube Boiler (Der Schulz Wasserrohrkessel). Carl Züblin. A general account of the Schulz modification of the Thornycroft water-tube boiler, with details of methods of manufacture, tests, and installation. Serial, Part I. 1800 w. Schiffbau—Oct. 12, 1904. No. 66270 D.

Chimneys.

Chimneys of the Interborough Rapid Transit Power House, New York City. Walter Kelsey. Illustrated detailed description of the plan of the six chimneys. 1400 w. Engr, U S A—Nov. 1, 1904. No. 65891 C.

Condensers.

Air Pumps. W. H. Booth. Considers some of the defects of independent condenser plants. 2200 w. Power—Nov., 1904. No. 65876 C.

Condensers for Steam Turbines. George I. Rockwood. On the designs for condenser systems, their cost, and especially a description of the injector or ejector condenser. 2200 w. Trans Am Soc of Mech Engrs, No. 056—Dec., 1904. No. 66070.

Connecting Rods.

Influence of the Connecting Rod Upon Engine Forces. Sanford A. Moss. Deduces a method for simply and yet exactly taking account of the influence of the weight and inertia of the connecting rod upon the forces transmitted by the ordinary slider crank-chain, such as is used in steam and gas engines. 3800 w. Trans Am Soc of Mech Engrs, No. 018—Dec., 1904. No. 66106.

Draft.

Draft in Ash Pans. Presented before the North-West Ry. Club. Extracts from replies to a letter of inquiry, with report of tests. 4000 w. Ry & Engng Rev—Nov. 26, 1904. No. 66377.

Engines.

Losses in Non-Condensing Engines.

James B. Stanwood. An extension of the discussion upon the relation of these losses, especially such as occur in non-condensing engines, with analysis of tests of a few leading types of these engines. 5400 w. Trans Am Soc of Mech Engrs. No. 034—Dec., 1904. No. 66105 C.

Interesting Results of the Tests of a Reeves Simple Engine. H. Diedrichs. Condensed report of a series of tests made to determine the steam consumption, mechanical efficiency and general behavior of the engine under various conditions of load. 1000 w. Sib Jour of Engng—Nov., 1904. No. 66087 C.

Exhaust Steam.

The Quality of Exhaust Steam. C. V. Kerr. Gives formulæ for determining the quality of the exhaust, and their application. 1200 w. Stevens Ind—Oct., 1904. No. 66401 D.

Utilization of Exhaust Steam in Connection with Low Pressure Steam Turbines. Mons. Leonce Battu. Presents the advantages of the Rateau system and some of its applications. Discussion and illustrations. 12000 w. Jour W Soc of Engrs—Oct., 1904. No. 66096 D.

Feed-Water.

Feed-Water Heating. R. T. Strohm. Discusses the economy, safety and purification secured by heating the feed-water, and the methods used. Ills. 2200 w. Am Elect'n—Nov., 1904. No. 65909.

On Some Water Softeners of a Novel Design. Dr. Alfred Gradenwitz. Illustrated description of the Breda water softener, with general remarks. 1800 w. Prac Engr—Nov. 4, 1904. No. 66043 A.

Purification of Water for the Production of Steam. J. O. Handy. Abstract of a paper read before the Int. Cong., St. Louis. A review of the methods for the removal of scale-forming matter as used in the United States. 6200 w. Elec Rev, N Y—Nov. 12, 1904. No. 66035.

Flue Gases.

Flue Gas Testing. W. H. Whysall. Illustrates and describes methods of testing, explaining the value of the information obtained. 2700 w. St Ry Rev—Oct 20, 1904. No. 65895 C.

Foaming.

A Bad Case of Discharge of Water with Steam from Water-Tube Boilers. A. Bement. An illustrated account of the investigations made to determine the cause and the remedies. 7000 w. Trans Am Soc of Mech Engrs, No. 020—Dec., 1904. No. 66077 C.

Marine Engines.

See Marine and Naval Engineering.

Navy Report.

See Marine and Naval Engineering.

Nozzles.

Pressures and Temperatures in Free Expansion. A. Borsody and R. Campbell Cairncross. Tables and diagrams, obtained experimentally, on the pressures in nozzles. Trans Am Soc of Mech Engrs, No. 055—Dec., 1904. No. 66099 C.

Pipe Joints.

Pipes and Joints for High Pressures. Franklin Riffle. Discusses the several types of pipes and joints that have recently been used for high pressures in the transmission of water, steam, and gas, with especial reference to Pacific Coast practice. Ills. 4200 w. Jour Assn of Engng Socs—Sept., 1904. No. 66165 C.

Unions and Flanges: Their Construction and Merits. Read before the Assn. of Steam Engrs. Discusses the various constructions of union couplings for steam pipes, with a view to determining the best design. 2300 w. Can Engr—Nov., 1904. No. 65990.

Piping.

High Pressure Steam Pipe Systems. Franz Koester. An illustrated review and comparison of late practice on the continent of Europe and in America. 3300 w. St Ry Rev—Oct. 20, 1904. No. 65894 C.

Power Plants.

See Electrical Engng., Generating Stations.

Smoke.

The Smoke Problem. F. J. Rowan. Considers the production, estimation, and prevention of smoke and the subject of municipal control. 2 plates. Discussion. 11000 w. Trans Inst of Engrs & Shipbuilders in Scotland—Oct. 25, 1904. No. 66411 D.

Specific Heat.

The Specific Heat of Superheated Steam. Sidney A. Reeve. Reviews information from various investigators and calls attention to the unsatisfactory present state of knowledge on this subject, urging its reinvestigation. 4000 w. Jour Worcester Poly Inst—Nov., 1904. No. 66410 C.

Steam Pumps.

See Mechanical Engng., Hydraulics.

Steam Turbines.

Simple Steam Turbine Engines. John Richards. Discusses the design, construction and operation of the various classes of these motors. Ills. 7500 w. Jour Assn of Engng Socs—Sept., 1904. No. 66163 C.

Steam Turbines (Dampfturbinen). M. F. Gütermuth. A review of the more recent steam turbines with diagrams showing the results of numerous tests. 4000 w. Zeitschr d Ver Deutscher Ing—Oct. 15, 1904. No. 66200 D.

We supply copies of these articles. See page 719.

Test on 500-Kilowatt Curtis Turbine Set at Cork. Gives the principal results of a series of trials on steam consumption, made by Charles H. Merz. 500 w. Engng—Nov. 18, 1904. No. 66385 A.

The De Laval Steam Turbine and Its Manufacture. Illustrated article describing details in the construction, and the methods of manufacture in the American works at Trenton, N. J. 4500 w. Mach, N Y—Nov., 1904. No. 65879 C.

See Marine and Naval Engineering.

Superheating.

The Assistance of Superheated Steam for Reducing the Cost of Electrical Energy. E. J. Fox. Remarks giving the writer's experience and showing the subject is deserving of the attention of those interested in the generation of electricity. 1500 w. Ir & Coal Trds Rev—Nov. 4, 1904. No. 66047 A.

Valves.

Steam Closing Stop Valves for Boilers. A. B. Willits. Illustrates and describes the old form of automatic stop valve, the advance to a steam closing stop valve, and the latest form. 1500 w. Ir Age—Nov. 24, 1904. No. 66317.

MINING AND METALLURGY

COAL AND COKE.

Briquettes.

The Improvement of Briquette Fuel for Minimising Smoke Production (Aufbesserung der Stein kohlen briketts zwecks Rauchverminderung). H. Schöndeling. Showing the influence of a suitable binding material and a heavy moulding pressure upon the smokelessness of briquettes. 1200 w. Glückauf—Nov. 5, 1904. No. 66261 D.

Charcoal.

Charcoal Fuel in the Ural (Holzkohlensorten in Ural). Ed. Juon. An account of the varieties of charcoal made in the iron districts of the Urals, furnishing practically the entire fuel for the Russian blast furnaces. 4000 w. Stahl u Eisen—Nov. 1, 1904. No. 66257 D.

Coal Cutting.

Two Years' Experience in Winning Coal by Machinery. F. O. Kirkup. Read before the N. Y. Eng. Branch of the Nat. Assn. of Col. Mgrs. An account of the writer's experience. Also discussion. 4000 w. Ir & Coal Trds Rev—Nov. 18, 1904. No. 66397 A.

Coal Mining.

See Industrial Economy.

Coke.

The German Coke Industry in the Last Ten Years (Die Deutsche Koksindustrie in den Letzten Zehn Jahren). Oskar Simmersbach. With statistics and diagrams showing the output of the various districts. 3000 w. Stahl u Eisen—Oct. 15, 1904. No. 66254 D.

Collieries.

Power Plants at Collieries. Discusses the principal economies that may be applied to modern collieries in Great Britain and the saving that would result. 1800 w. Mech Engr—Oct. 29, 1904. No. 65974 A.

Dawdon Colliery.

The New Winning at Dawdon Colliery A report of progress at the Thereau pit and the Castlereagh pit. These shafts are to be sunk to a depth of 1800 ft. and are 20 ft. in diameter. 1200 w. Col Guard—Nov. 18, 1904. No. 66383 A.

Explosions.

Coal Dust Explosions in Upper Silesia (Ueber Kohlenstaub explosionen in Oberschlesien). H. Knochenhauer. Detailed accounts of a number of explosions in coal mines, due to the ignition of the dust in the air. 5000 w. Glückauf—Oct. 29, 1904. No. 66260 D.

Hungary.

Coal in Hungary. From a monograph by Alexander von Kaliezinsky. On the character of the deposits and the development. 700 w. Eng & Min Jour—Nov. 24, 1904. No. 66327.

New Fields.

The Alberta Coal Field. L. K. Armstrong. General information concerning the Canadian coal fields of Alberta and East Kootenay in British Columbia. Map. 1500 w. Min Rept—Nov. 24, 1904. No. 66337.

South Wales.

The Coal Measures of the Valley of the Gwendraeth-farm in South Wales. T. C. Cantrill and E. E. L. Dixon. From the Genl. Surv. of the United Kingdom . An account of the veins and their working, faults, disturbances, etc. 4000 w. Ir & Coal Trds Rev—Nov. 4, 1904. No. 66049 A.

Spontaneous Combustion.

The Reduction of Risk from Fires Caused by Spontaneous Combustion of Soft Coal. Advice from a bulletin of the Home Insurance Co., of New York, prepared by F. M. Griswold. 800 w. Eng News—Nov. 10, 1904. No. 65997.

We supply copies of these articles. See page 719.

Washington.

Notes on the Mines of Kittitas County, Washington. J. D. Bone. An account of a remarkably rich region yielding abundance of bituminous coal, and also gold, copper and iron. 1000 w. Min Rept—Oct. 27, 1904. No. 65858.

COPPER.

Arizona.

The Genesis of the Copper-Deposits of Clifton-Morenci, Arizona. Waldemar Lindgren. A résumé of some of the conclusions reached during a study of the copper-deposits near Clifton. 14000 w. Trans Am Inst of Min Engrs—Sept., 1904. No. 66357 C.

The Silverbell Mountains, Arizona. W. G. Barney. Describes this region brought into notice by the recent building of the Arizona Southern R. R., and the copper deposits being developed. 1300 w. Eng & Min Jour—Nov. 10, 1904. No. 66004.

Assaying.

The Iodimetric Determination of Copper. Andrew M. Fairlie. Describes a method which claims to have eliminated all the objectionable features of the precipitation by aluminum. 1400 w. Eng & Min Jour—Nov. 17, 1904. No. 66124.

Colorado.

Copper Mining in the Encampment, Wyoming, and Pearl, Colorado, Districts. Thomas T. Read. Considers these districts on the Wyoming-Colorado boundary, describing the development. 800 w. Min Rept—Nov. 3, 1904. No. 65963.

Electro-Metallurgy.

See Electrical Engineering, Electro-Chemistry.

Native.

Mass Copper. Extracts from reports published in 1857, 8, & 9, in regard to development at the Minnesota mines. 2000 w. Eng & Min Jour—Nov. 10, 1904. No. 66001.

Ore Deposits.

Copper Ores in the Cascade Mountains. R. H. Stretch. Map with notes on the connection of the sulphide ores of copper with the associated rocks. 2000 w. Eng & Min Jour—Nov. 17, 1904. No. 66125.

The Theory of Copper Deposition. Alfred C. Lane. A review of what is known concerning the copper of Lake Superior and of the theories regarding the origin. 4000 w. Am Geol—Nov., 1904. No. 66060 D.

Smelting.

Roasting at the Tyee Smelter. E. Jacobs. Describes the treatment of the ore before it reaches the furnace, particularly the arrangement, appointments and operating methods of the roasting yard. The ore is principally chalcopyrite carrying gold, silver and zinc as well as copper. Ills. 1500 w. Eng & Min Jour—Nov. 10, 1904. No. 66000.

Yukon.

White Horse Copper Camps, Yukon Territory. W. M. Brewer. An account of the development of southern Yukon and its mines, and some of the difficulties encountered. 2500 w. Min & Sci Pr—Nov. 5, 1904. No. 65038.

GOLD AND SILVER.

Black Hills.

The Ore Deposits of the Northern Black Hills. T. D. Irving. Describes this productive region and its ore deposits. 2000 w. Min Rept—Oct. 27, 1904. No. 65855.

British Columbia.

Smelters and Smelting Practice in British Columbia. William M. Brewer. An illustrated review of the rapid growth and expansion of the smelting industry in the last fifteen years. 4000 w. Engineering Magazine—Dec., 1904. No. 66283 B.

Crushing.

Crushing in Cyanide Solution, as Practiced in the Black Hills, South Dakota. Charles H. Fulton. Describes the character of the ores the general features of the process, the precipitation, etc., giving the cost of treatment. 8000 w. Trans Am Inst of Min Engrs—Sept., 1904. No. 66365 C.

Cyanide.

Cyanide Practice at the Maitland Properties, South Dakota. John Gross. Describes the ore, and the mill practice, giving statistical data based on a daily tonnage of from 110 to 120 tons. Ills. 5000 w. Trans Am Inst of Min Engrs—Sept., 1904. No. 66364 C.

Deep Leads.

The Deep Leads of Victoria. H. L. Wilkinson. A description of these auriferous deposits, their location, draining and working. Map. 2200 w. Aust Min Stand—Oct. 20, 1904. Serial. 1st part. No. 66378 B.

Laboratory.

The equipment of a Laboratory for a Smelting-Plant. Hubert Haas. Describes a laboratory for metallurgical chemistry and technical analyses built by the writer in California. 2000 w. Trans Am Inst of Min Engrs—Sept., 1904. No. 66363.

Ontario.

The Mines of Ontario. W. E. H. Carter. Read before the Can. Min. Inst. A brief review of the present status of the mining industry, especially in western Ontario. The gold mines, placers, etc. are dealt with in the present article. 3000 w.

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Can Min Rev—Oct. 31, 1904. Serial, 1st part. No. 65958 B.

Oregon.

The Granite Hill Mines of Southern Oregon. An account of the development of these gold-quartz mines, with illustrations. 1400 w. Min & Sci Pr—Nov. 5, 1904. No. 66039.

Ores.

Preliminary examining of Milling Ores. Alfred Harvey. On the importance of testing ores to minimize the risk in designing a mill to treat an ore satisfactorily. 1200 w. Min & Sci Pr—Oct. 29, 1904. No. 65966.

Patio Process.

The Modern Patio Process. Arthur H. Halloran. Describes the primitive method used in Mexico, Peru, and Chili, and recent improvements introduced which even further simplifies and cheapens this method. 1500 w. Illus. Min & Sci Pr—Oct. 29, 1904. No. 65967.

Precipitate.

Some Studies on "the White Precipitate" Formed in the Zinc Boxes of the Cyanide Works. Prof. A. Prister and Dr. B. Bay. Gives analyses made to determine the total cyanide, and the bases present in the white precipitate. Brief discussion. 4500 w. Jour of Chem, Met, & Min Soc of S Africa—Sept., 1904. No. 66175 E.

Rand.

Mining and Metallurgy on the Rand. E. M. Weston. Gives a record of recent progress. 2800 w. Aust Min Stand—Oct. 6, 1904. Serial. 1st part. No. 66351 B.

The Analyses of Some Witwatersrand Soils. Edw. H. Croghan. General discussion. 3000 w. Jour of Chem, Met, & Min Soc of S Africa—Sept., 1904. No. 66176 E.

Yukon.

Hydraulicking in the Yukon Region. C. R. Settlemeier. Describes the conditions of this region and the methods used. Ills. 2700 w. Min & Sci Pr—Nov. 19, 1904. No. 66338.

IRON AND STEEL.

Blast-Furnaces.

Improvements in the Mechanical Charging of the Modern Blast-Furnace. David Baker. An illustrated account of skip-hoist experiments, and the conclusions. 4000 w. Trans Am Inst of Min Engrs—Sept., 1904. No. 66358 C.

Notes on the Blast-Furnace. John M. Hartman. Suggestions for the management of blast-furnaces. 3000 w. Ir Trd Rev—Nov. 10, 1904. No. 66019.

Special Forms of Blast-Furnace Charging-Apparatus. T. F. Witherbee. Illustrated description of various forms of charging apparatus, suggesting that better results in running may be had by charging nearer to the center. 1800 w. Trans Am Inst of Min Engrs—Sept., 1904. No. 66362.

The Pyrometer in Blast-Furnace Practice. S. H. Stupakoff. Read before the Pittsburg Found. Assn. Gives details of interest in regard to the application of the thermo-electric pyrometer to blast-furnaces, with brief remarks on other pyrometers. 3300 w. Am Mfr & Ir Wld—Nov. 17, 1904. No. 66119.

Dunderland Mines.

The Edison Process at the Dunderland Mines. W. Simpkin and J. B. Ballantine. Read before the Inst. of Min. & Met. Brief illustrated description of the Edison process of crushing and grinding as it has been applied to iron ore franklinite, limestone, etc. 3500 w. Ir & Coal Trds Rev—Oct. 28, 1904. No. 65987 A.

Ferro-Titanium.

The Titaniferous Charcoal Iron of Turrach in Upper Styria (Ueber Titanhaltiges Holzkohlen-Roheisen von Turrach in Obersteiermark). J. Hörhager. Giving analyses of the irons showing their availability for the production of ferro-titanium. 3500 w. Oesterr Zeitschr f Berg u Huttenwesen—Oct. 22, 1904. No. 66234 D.

Fine Ores.

The Injurious Action of Fine Ores upon the Blast Furnace (Feinerze als Ursache von Hochofenstörungen). Dr. Aloys Weiskopf. An examination of the manner in which fine ores erode the interior of the furnace and affect the working. 3500 w. Stahl u Eisen—Nov. 1, 1904. No. 66256 D.

Iron Industry.

See Industrial Economy.

New District.

A New, Promising Lake Superior Iron District. Kirby Thomas. Describes the Cuyuna district in Minnesota. Map. 2500 w. Min Wld—Nov. 5, 1904. No. 65941.

Ore-Handling.

Ore-Handling Machinery on the Great Lakes. Illustrated description of some of the more important varieties of ore handling machinery in use, showing the method of removing the ore from vessels and placing it on cars. 4400 w. Naut Gaz—Nov. 3, 1904. No. 65961.

Pig Iron.

Notes on Southern Pig Iron. Eliot A. Kebler. Read before the Pittsburg Found. Assn. Information of interest. 1200 w. Ir Age—Nov. 17, 1904. No. 66110.

Rolling Mills.

Some of the Significant Features of American Rolling Mill Practice. D. F.

Nisbet. Notes on steam generation, engines for roll trains, hydraulic systems, electrical appliances, ingot stripping, pit furnaces, mills, etc. Ills. 6000 w. Ir Trd Rev—Oct. 27, 1904. No. 65863.

The New Universal Mill of the Burbach Works (Die Neue Universalstrasse der Burbacher Hütte). Fr. Frölich. Details and photographs of a mill built by the Duisburg works and installed at Burbach, including direct-connected engine and steam plant. 2000 w. Zeitschr d Ver Deutscher Ing—Oct. 29, 1904. No. 66206 D.

Smelting.

Electric Smelting of Iron and Steel. J. H. Stansbie. Read before the Staffordshire Iron & Steel Inst. Brief notes on the construction and working of the electric furnace and its use for smelting purposes. 1200 w. Ir & Coal Trds Rev—Nov. 4, 1904. No. 66048 A.

Tropenas Process.

The Small Converter Problem. Arthur Simonson. Information explanatory of the Tropenas Steel Process and its advantages. 2800 w. Foundry—Nov., 1904. No. 65889.

MINING.

Compressed Air.

Compressed Air in Mine Operation. Lucius I. Wightman. An advocacy of compressed air for mining work, presenting its advantages. Ills. 2500 w. Min Mag—Oct., 1904. No. 66084 C.

Greece.

The Mines of Laurium, Greece. Henry F. Collins. Describes the geology of the region, and the deposits of silver, lead, iron, and zinc ores. Ills. 3000 w. Eng & Min Jour—Nov. 10, 1904. No. 66003.

Haulage.

Electrical and Steam Haulage. Neil Hutchings. An illustrated description of the haulage system at Slope No. 3, Pratt mine, of the Tennessee Coal, Iron & Railroad Co., at Ensley, Alabama. 2200 w. Mines & Min—Nov, 1904. No. 65930 C.

Electric Mine Haulage. W. B. Clarke. Considers the electric mine locomotive and its adaptation to underground haulage. Ills. 2000 w. Min Mag—Oct., 1904. No. 66083 C.

Notes on the Application of an Oil Engine to Main and Tail and Endless Rope Haulage Combined. W. C. Blackett. Read before the N. of Eng. Branch of the Nat. Assn. of Col. Mgrs. An account of the use of oil ngines in secondary haulage, describing the method. Ills. 2000 w. Ir & Coal Trds Rev.—Nov. 18, 1904. No. 66398 A.

Hoisting.

Head-Frames and Hoists in the Joplin District. W. R. Crane. Illustrates and describes the construction of head-frames and the methods of hoisting employed in the lead and zinc mines, which differ greatly from those used in other districts. 4000 w. Min Mag—Oct., 1904. No. 66081 C.

Hoists and Hoisting in the Interior Coal Fields. George S. Rice. Describes the arrangements where the conditions to be met are shallow shafts, rapid hoisting, and small labor costs. Ills. 2200 w. Min Mag—Oct., 1904. No. 66082 C.

Improved Controlling Appliances for Winding Engines (Nouveaux Evite-Molettes). H. Schmerber. Describing especially the electric and other systems, shown at the exposition at Arras, for controlling and regulating winding engines for mines together with brakes and safety appliances. Two articles. 3000 w. Génie Civil—Oct. 22, 29, 1904. No. 66213 each D.

Present Practice of Deep Hoisting on the Mines of the Rand. J. B. Carper. Description, with illustration, of the Whiting system and its application to these mines, the cost, etc. 1800 w. Min Jour—Nov 12, 1904. No. 66173 A.

The Electric Winding Plant at the Ligny-les-Aire Mines Elektrische Fördermaschine für die Compagnie des Mines de Ligny-les-Aire). Details and general arrangement of winding plant for a depth of 400 metres, installed in Northern France. 2000 w. Zeitschr d Ver Deutscher Ing—Oct. 22, 1904. No. 66204 D.

The Hoisting Problem. James R. Thompson. Read before the Lake Superior Min. Inst. Discusses the relation of the underground requirements, the engineering, mechanical and financial consideratons. 5000 w. Mines & Min—Nov., 1904. No. 65932 C.

The Tamarack Hoisting Engine. Illustrates and describes an engine having interesting features and a capacity of 5000 h. p. 2000 w. Power—Nov., 1904. No. 65874 C.

Mining Debris.

Débris-Restraining Barriers of the Yuba River. Capt. Wm. W. Harts. An illustrated article explaining the plan proposed by the California Débris Commission for the treatment of this river which suffered from the accumulation of mining detritus. 3000 w. Sci Am Sup—Nov. 19, 1904. No. 66118.

Ore Elevators.

Notes on Ore Bucket Elevators. Alfred Harvey. Describes a few types most commonly used, giving information in regard to satisfactory speeds and diameters of head pulleys. Ills. 1500 w. Min Rept—Nov. 17, 1904. No. 66174.

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Respirator.

Recent Investigations upon the Use of a Working Respirator Apparatus (Neue Untersuchungen über die Erfordernisse eines zur Arbeit Brauchbaren Rettungsapparates). B. Dräger. Describing recent devices for artificial respiration for life-saving service in mines. 3000 w. Glückauf—Oct. 15, 1904. No. 66259 D.

Shafts.

A Concrete-Lined Shaft for the U. S. Coal & Coke Co. Francis Donaldson. Illustrated description of two elliptical shafts, lined with concrete, recently completed in W. Va. 1200 w. Eng News—Nov. 3, 1904. No. 65925.

Richmond No. 3 Shaft. Frank G. Wolfe. Illustrates and describes methods employed in sinking through quicksand near Scranton to connect with workings below. 1500 w. Mines & Min—Nov., 1904. No. 65933 C.

Shaft Sinking Through Quicksand. H. B. Sturtevant. From Pro. of L. Sup. Min. Inst. A description of methods employed at Susquehanna mine, Hibbing, Minn. 1800 w. Mines & Min—Nov., 1904. No. 65934 C.

Valuation.

Variation of Ore Values—Caution in Valuing Mines. A. Lakes. Observations of an experienced mine examiner. 1200 w. Min Rept—Nov. 3, 1004. No. 65965.

Ventilation.

Small Quick-Running Fans for Mine Ventilation. James Tonge. An illustrated account of some new ventilators for this purpose and the advantages claimed. 1700 w. Mines & Min—Nov., 1904. No. 65929 C.

MISCELLANY.

Aluminium.

Note on a Suggested New Source of Aluminium. Buena Pool. On the utilization of the laterite deposits of India, in which the aluminium is present in the hydrated form. 1200 w. Elec Engr, Lond—Oct. 28, 1904. No. 65976 A.

Bitumen.

Bitumen: Its Consumption in the United Kingdom and Its Production in Trinidad. W. Pollard Digby. Shows the volume and source of the United Kingdom's import of bitumen for the last 15 years. 1000 w. Elec Engr, Lond—Oct. 28, 1904. No. 65977 A.

Chile.

A Geological Cross-Section of the Western Cordillera Along the Rio Husses. A record of facts collected during several hurried journeys, with topographical map and a cross-section. 2800 w. Trans Am Inst of Min Engrs—Nov., 1904. No. 66360.

Fluor Spar.

Fluor Spar Deposits of the Kentucky-Illinois District. H. Foster Bain. On the grades and genesis of the ore, and the geology of the district. 2500 w. Mines & Min—Nov., 1904. No. 65931 C.

Manganese.

Manganese. Lionel C. Ball. Introductory to reports on the manganese deposits of Queensland, dealing with the mineralogy, chemistry, metallurgy, uses, markets, and occurrence. 4500 w. Queens Gov Min Jour—Sept. 15, 1904. No. 65905 B.

Manganese in Cyanide Solutions. J. E. Clennell. Describes a process based on the method given by C. and J. Beringer for the colorimetric estimation of manganese in ores and compounds free from chlorides. 600 w. Eng & Min Jour—Nov. 24, 1904. No. 66325.

Oil Region.

The Flathead Valley—A Description of the New East Kootenay Oil Region. D. B. Boyle. Illustrated. 900 w. B C Min Rec—Nov., 1904. No. 65989 B.

Quicksilver.

Quicksilver in Pan Amalgamation. W. J. Adams. An explanation of the causes of the flouring of quicksilver. 900 w. Min & Sci Pr—Nov. 5, 1904. Serial. 1st part. No. 66037.

Slags.

The Formation of Slags in Metallurgical Operations (La Formation des Scories dans les Operations Métallurgiques). W. Mathesius. An examination of the chemical composition of various slags, their formation, and some of their useful applications. 4000 w. Rev Gen des Sciences—Oct. 15, 1904. No. 66235 D.

Tin.

Tin in the United States. F. Lynwood Garrison. Briefly reviews the localities where tin has been found and exploited, commenting on the recent discovery of tin in Alaska. 3000 w. Eng & Min Jour—Nov. 24, 1904. No. 66328.

Tungsten.

Tungsten: Its Use and Value. States the chief sources, with some of its uses, and present value. 900 w. Eng & Min Jour—Nov. 10, 1904. No. 66002.

Vanadium.

Extraction of Vanadium from Natural Vanadate of Lead (Extraction du Vanadium du Vanadate de Plomb Naturel). H. Herrenschmidt. Describing the treatment used for the vanadate of lead from the Santa Marta mines, Spain, and the subsequent production of ferro-vanadium. 800 w. Comptes Rendus—Oct. 24, 1904. No. 66232 D.

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RAILWAY ENGINEERING

CONDUCTING TRANSPORTATION.

Accidents.

Railroad Accidents in the United States. Edward A. Moseley. Comments on the increase in railroad accidents, discussing the causes, and suggesting remedies. 4200 w. Rev of Revs—Nov., 1904. No. 65907 C.

The Causes of Accidents on American Railways. F. W. Haskell. Attributing the frequency of disasters to official connivance in the habitual disregard of rules. 4000 w. Engineering Magazine—Dec., 1904. No. 66282 B.

Operation.

Railroad Operation in the United States. Sidney Graves Koon. An investigation of the general tendency in recent years, based on statistics given in a paper by H. Ward Leonard. 1200 w. Sib Jour of Engng—Nov., 1904. No. 66089 C.

MOTIVE POWER AND EQUIPMENT.

Air Brakes.

Train Pipe Leakage, and Speed of Air Pump. P. J. Langan. On the importance of maintaining the equipment, the effect of fast running on pumps, their need of inspection, etc. 2000 w. Loc Engng—Nov., 1904. No. 65969 C.

Cars.

First-Class Salon for the South-Eastern and Chatham Railway. Illustrated description of handsome first-class carriages. 2-page plate. 700 w. Engng—Oct. 28, 1904. No. 65982 A.

Steel Cars. Extracts from a paper by J. F. MacEnulty, read at meeting of the New England R. R. Club. Presents the advantages of this type of construction, and attempts to show that such cars are more economical than modern cars. 2000 w. R R Gaz—Vol. XXXVII., No. 24. No. 66329.

Combustion.

Combustion, or the Source of Energy in the Locomotive. T. J. Henderson. A discussion of the question of fuel economy. 4000 w. Pro Pacific C Ry Club, Oct. 15, 1904. No. 66080 C.

Electric Locomotives.

Construction and Characteristics of Electric Locomotives for the New York Central & Hudson River R. R. Illustrated detailed description, calling attention to the new features. 3000 w. Eng News—Nov. 17, 1904. No. 66134.

Electric Railway Locomotives for the New York Central. Illustration and principal dimensions of these locomotives, with description and general remarks. 1400 w. Sci Am—Nov. 12, 1904. No. 66007.

North-Eastern Railway Electric Locomotive. Illustrated detailed description. 1500 w. Tram & Ry Wld—Nov. 10, 1904. No. 66356 B.

The First Electric Locomotive for the New York Central. Illustrated description of the powerful high-speed electric locomotive officially tried at Schenectady on Nov. 12. 2500 w. Ir Age—Nov. 17, 1904. No. 66108.

Fire Box.

Locomotive Boiler with Water-Tube Fire Box (Lokomotivkessel mit Wasserrohr Feuerbuchse). G. Elbel. A description of the Brotan boiler, combining a water-tube fire box with the fire-tube shell. 2000 w. Glasers Annalen—Oct. 15, 1904. No. 66225 D.

India.

A New Indian Train de Luxe. Illustrated description of a special limited express between Bombay and Poona. 1000 w. Loc Engng—Nov., 1904. No. 65968 C.

Locomotives.

A Proposed Compound Express Locomotive. Chas. S. Lake. Illustrates and describes a 4-4-2 passenger engine compounded on Mr. Rickie's system, discussing its use for highest grade express passenger duty under British restrictions. 2200 w. Transport—Oct. 28, 1904. No. 65971 A.

A Trip on the Big 2700. Angus Sinclair. Describes a ride on a four-cylinder balanced compound locomotive on the C. B. & Q. R. R. 1500 w. Loc Engng—Nov., 1904. No. 65970 C.

Baldwin Four-Cylinder Balanced Compound Locomotive. W. J. McCarroll. Read before the Traveling Engrs'. Assn. Remarks on the value of compounding, with illustrated description of this engine and its action. 3800 w. Ry & Engng Rev—Nov. 12, 1904. No. 66040.

Boston & Maine 10-Wheel Passenger Locomotive. Illustrations and discussions of powerful engines. 500 w. Ry Age—Nov. 11, 1904. No. 66018.

Eight-Coupled Locomotive for Goods Traffic; Great Central Railway. Brief, illustrated description, with two-page plate. 400 w. Engng—Nov. 18, 1904. No. 66390 A.

Fuel Consumption of Locomotives. G. R. Henderson. Gives a diagram for solving problems in fuel consumption, with

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explanation of its use. 2300 w. Trans Am Soc of Mech Engrs, No. 046—Dec., 1904. No. 66073.

German Four-Cylinder Balanced Compound Locomotive, with Superheater, at the St. Louis Exhibition. Illustrated detailed description of this engine, which is one of 30 engines for the Prussian State Railways. 1800 w. Eng News—Nov. 24, 1904. No. 66332.

New Locomotives for the Paris Belt Railroad. Abstract of an article by J. Koechlin, in the *Revue Generale des Chemins de Fer.* Illustrated description of engines designed for local passenger service. 2300 w. R R Gaz—Vol. XXXVII, No. 21. No. 65918.

Powerful Prairie Type Passenger Locomotives. Illustration, description, and general dimensions of the heaviest passenger locomotives ever built, noteworthy for their power, heavy wheel loads and the wheel arrangement. 700 w. Am Engr & R R Jour—Nov., 1904. No. 65880 C.

Recent Locomotive Work on the London and North-Western Railway. Charles Rous-Marten. A review of the manner in which the time-table promises have been fulfilled. The present article especially considers Mr. Whale's new engines. 2800 w. Engr, Lond—Nov. 4, 1904. Serial. 1st part. No. 66054 A.

Standard Locomotives for the Southern Pacific. Illustrations, with brief descriptions of engines of the consolidation, Atlantic, Pacific, and 6-wheel switching types. 400 w. Ry Age—Nov. 25, 1904. No. 66315.

The Mallet Articulated Locomotive at the St. Louis Exhibition. H. W. Hanbury. Especially discusses the intercepting, reducing and emergency valves, which are the leading feature of the Richmond System of Compounding. 1500 w. Engng—Nov. 11, 1904. No. 66199 A.

Locomotive Trials.

Comparative Trials of Locomotives Using Saturated Steam and Using Moderately Superheated Steam. Wm. Strohl, in *Zeitschrift des Ver. deut. Ing.* Abstract of report of trials on the Prussian State Railway. 4900 w. Bul Int Ry Cong—Oct., 1904. No. 66181 E.

Road Tests of Brooks Passenger Locomotives. E. A. Hitchcock. Gives results representing every-day practice on two types of machines, giving illustrated description of apparatus, and methods. 2700 w. Trans Am Soc of Mech Engrs, Nov. 054—Dec., 1904. No. 66100 C.

Locomotive Valves.

The Young Valve and Gear for Locomotives. Illustrated detailed description of a system of rocking valves, designed by O. W. Young and carefully tested. 2000 w. R R Gaz—Vol. XXXVII, No. 21. No. 65919.

Motor Cars.

Auto Cars on French Railways. Illustrates and describes types put in service, especially the Purrey carriages. 1600 w. Ry Age—Nov. 11, 1904. No. 66016.

Extension of the Great Western Motor Coach Services. Gives information concerning this service and its success. 1500 w. Engr, Lond—Nov. 4, 1904. No. 66056 A.

New Steam Motor Cars for Railway Service (Neue Dampfmotorwagen im Eisenbahnbetrieb). Dr. Alfred Brunn. With numerous illustrations of self-propelled cars for local and special service. Two articles. 6000 w. Ill. Zeitschr f Klein u Strassenbahnen—Oct. 19, Nov. 2, 1904. No. 66280 each D.

The Use of Independent Motor Cars on Railways. Philip Dawson. A discussion of this subject, describing the various motor cars that have come into use and concluding that the car driven by a petrol. or gasoline motor is the best thus far tried. 11000 w. St Ry Jour—Nov. 5, 1904. No. 65942 C.

Resistance.

Train Resistance. Chester A. Crandall. Gives first a comparison of the calculated with the actual train resistance; second, an analysis of the several factors which influence train resistance; third, a comparison of the best-known formulæ. 1200 w. R R Gaz—Vol. XXXVII, No. 21. No. 65920.

Superheating.

The Application of Superheated Steam to Locomotives (Die Anwendung des Heissdampfes im Lokomotivbetriebe). Ernst Happel. A discussion of the economy to be effected, and a description of a simple form of superheater for locomotive boilers. 1200 w. Glasers Annalen—Nov. 1, 1904. No. 66227 D.

Train.

The New Haven's Merchants' Limited Train. Illustrates and describes two complete new Pullman trains placed recently on 5-hour service between New York and Boston. 800 w. Ry Age—Nov. 25, 1904. No. 66314.

Truck.

A New Design of Steel Motor Truck for Heavy Electric Traction Service. Illustrates and describes a truck for heavy high-speed electric railway operation. 1500 w. St Ry Jour—Oct. 29, 1904. No. 65865 C.

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Water Glasses.

The Breakage of Tubes of Water-Level Indicators (Rupture des Tubes Indicateurs de Niveau d'Eau). M. Defaucon-pret. Describing the devices used on the Northern Railway of France for the protection of the men from injury by the breakage of water-glass tubes. 2500 w. Rev Gen d Chem de Fer—Sept., 1904. No. 66249 G.

NEW PROJECTS.

Argentina.

Argentine Railway Progress. Charles M. Pepper. An account of the activity in railway enterprises, with map showing lines built and projected. 1500 w. Ry Age—Nov. 11, 1904. No. 66017.

Lake Baikal.

The Lake Baikal Railway. Particulars from the report of a Russian engineer in regard to this recently completed section of the great Siberian Railway. 2000 w. Engng—Nov. 18, 1904. No. 66388 A.

New Road.

The Grand Trunk Pacific. A reprint, almost in full, of an article by W. L. Mackenzie King, in the *Quarterly Journal of Economics*, which analyses in detail the agreement made by the Canadian Government, and comments on the policy to be tried. 4500 w. R R Gaz—Vol. XXXVII, No. 24. No. 66331.

PERMANENT WAY AND BUILDINGS.

Berlin.

The Construction of the Görlitz Railway and Its Connections Between Berlin and Grünau (Ausbau der Görlitzer Vorortstrecke und ihrer Anschlusse zwischen Berlin und Grünau). H. Biedermann. An illustrated account of recent extensions of suburban railway connections in the vicinity of Berlin. 4000 w. 2 plates. Glasers Annalen—Nov. 1, 1904. No. 66226 D.

Blacksmith Shop.

Equipment for a Modern Blacksmith Shop for Railroad Work. A. W. McCaslin. Presented before the Nat. R. R. Mas. Blacksmiths' Assn. Describes the requirements of a model shop. 2300 w. Ry Mas Mech—Nov., 1904. No. 65988.

China.

The Actual Building of a Chinese Railway. Justin Burns. The second article describes the earthwork, bridges, track and train service of the Canton-Hankow Railway. 4000 w. Engineering Magazine—Dec., 1904. No. 66286 B.

Cross-Ties.

The Railroad Cross-Tie Problem. S. Whinery. Considers the subject of crossties and other forms of support for tracks, giving a summary of the conclusions reached and some of the reasons leading to them. Ills. 2500 w. R R Gaz—Vol. XXXVII, No. 21. Serial. 1st part. No. 65921.

Curves.

Vertical Railway Curves. H. J. Randall. Considers curves to round off the angle made by the change of grade, discussing what justification there is for making the curve from 200 to 400 feet or more in length, showing the advantage of increasing the length is much greater for short trains than long ones. Ills. 5000 w. Jour Assn of Engng Socs—Sept., 1904. No. 66166 C.

Improvements.

Improvements on the Morris & Essex Division of the Lackawanna R. R. Explains recent changes made necessary by the great increase in population near New York, describing and illustrating important features of the work. 3500 w. Eng Rec—Nov. 12, 1904. Serial. 1st part. No. 66025.

Rails.

On the Discussion of Rails for Lines with Fast Trains (Subject II., for Discussion at the Seventh Session of the Railway Congress). J. W. Post. Investigation of the question in general and the experience, in particular, of certain managements mentioned, with conclusions. 7400 w. Tables and figures. Bul Int Ry Cong—Oct., 1904. No. 66178 E.

Rail Bonding. A. Henrick Jackson. An illustrated article based on information from the paper by Percy S. Sheardown, with amplifications and variations. 3200 w. Aust Min Stand—Oct. 20, 1904. No. 66379 B.

Shops.

Improvements at the Spencer Shops of the Southern Railway. An illustrated description of the enlargement of locomotive repair shops in North Carolina. 2500 w. R R Gaz—Vol. XXXVII, No. 24. No. 66330.

Keyser Valley Car Shops of the Delaware, Lackawanna & Western. Illustrated detailed description of a large plant, near Scranton, Pa., for repairing cars. 1000 w. Ry Age—Oct. 28, 1904. No. 65860.

New Power House—West Albany Shops. Illustrated description of this new power house and its equipment. It is a part of the plan for modernizing the method of driving. N. Y. C. & H. R. R. R. 1500 w. Am Engr & R R Jour—Nov., 1904. No. 65881 C.

Signals.

A Low-Pressure Pneumatic Interlocking Signal Station (Description d'une Cabine d'Enclenchements à Trajecteurs

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Pneumatiques à Basse Pression). E. Despons. Describing experiments on pneumatic signals made by the Northern Railway of France. 7500 w. Rev Gen d Chem de Fer—Oct., 1904. No. 66230 G.

Safety Appliances and Block Signals—Proposed Bill Requiring Use of the Block System. Report of the Committee on Safety Appliances and Block Signals at the Sixteenth Annual Convention of the Nat. Assn. of Ry. Com. at Birmingham, Alabama. 5500 w. Ry Age—Nov. 18, 1904. No. 66158.

Terminals.

Facilities at Railroad Terminals. Albert P. Greenfelder. Discussion at the Int. Engng. Cong. at St. Louis, of the facilities required in large stations, with suggestions for improvements. 2000 w. Ry & Engng Rev—Oct. 29, 1904. No. 65859.

Great Northern Terminal Improvments at Seattle. Illustrates and describes improvements found necessary, including the construction of a tunnel under the business district. 2000 w. R R Gaz—Vol. XXXVII, No. 21. No. 65917.

New Yards and Terminal Approaches at Washington, D. C. W. F. Strouse. Illustrates and describes the new yards and terminal facilities, the bridges which carry the tracks over the streets, retaining walls, etc. 3300 w. R R Gaz—Vol. XXXVII, No. 22. No. 66006.

The Steel Construction in the Wabash Terminal at Pittsburg. Illustrated detailed description of the construction of the Wabash trainshed. 1800 w. Eng Rec—Nov. 12, 1904. No. 66030.

The Washington Terminal Improvement. W. F. Strouse. An illustrated general description of the Union Station and the elimination of grade crossings in Washington. 7200 w. Eng Rec—Nov. 5, 1904. No. 65946.

The Washington Terminal Improvements of the Baltimore & Ohio and the Pennsylvania Railways. W. F. Strouse. An illustrated article describing the work of eliminating grade crossing, the terminal stations, etc. 6000 w. Eng News—Nov. 10, 1904. No. 65998.

Tidewater Terminal of the Western Maryland at Baltimore. An illustrated description of the new terminal at Port Covington. 1000 w. R R Gaz—Vol. XXXVII, No. 23. No. 66159.

MISCELLANY.

Light Railways.

On the Question of the Direct Financial Co-operation by the State and by Localities Interested in the Development of Light Railways (Subject XVIII for Discussion at the Seventh Session of the Railway Congress). C. Colson. Statement of the results obtained in Belgium, France, Germany and the United Kingdom. 23400 w. Bul Int Ry Cong—Oct., 1904. No. 66179 E.

Purchase.

The Ontario & Western Transfer. Editorial, explaining the situation that led to the purchase of this road by the New York, New Haven & Hartford. 1200 w. R R Gaz—Vol. XXXVII, No. 21. No. 65916.

Research Bureau.

Proposed Central Technical Research Bureau for the Austrian Railways. Dr. Wilhelm Exner. Lecture to the Austrian Soc. of Engrs. and Archts. Translated from *Zeitschrift des Oesterreichischen Ing. und Arch. Ver.* A statement of the proposal and arguments favoring it. 9200 w. Bul Int Ry Cong—Oct., 1904. No. 66180 E.

Tunnels.

See Civil Engineering Construction.

TRAFFIC.

Freight.

Comparative Cost of Fast and Slow Freight Service. W. B. Poland. A report of data collected during the months of Jan. and Feb., 1904, and conclusions. 1200 w. Ry Age—Nov. 25, 1904. No. 66316.

India.

Passenger Traffic on Indian Railways. Concerning traffic where the average number of passengers in a train is greater than in any other country. 1500 w. Engr, Lond—Nov. 18, 1904. No. 66393 A.

Suburban.

On the Question of the Suburban Traffic (Subject XII for Discussion at the Seventh Session of the Railway Congress). A. W. Sullivan. Summary of information in response to a circular of inquiry. 4 tables and figures, with 46 photographs. 9900 w. Bul Int Ry Cong—Oct., 1904. No. 66177 E.

STREET AND ELECTRIC RAILWAYS

Air-Brakes.

Energy Required in Watt Hours When Braking with Air. Frank B. Rae. Urging the equipment of cars with air-brakes, and giving information concerning the determination of the proper size, application,

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cost, etc. 2500 w. St Ry Jour—Nov. 5, 1904. No. 65944 C.

Altered Cars.

Converting Summer to Winter Cars in Cleveland. Illustrated description of the alterations made. 1000 w. St Ry Jour—Nov. 19, 1904. No. 66183 C.

Cable Railroad.

The Mürren Cable Railroad in the Swiss Alps. Brief description of the road connecting Lauterbrunnen and Mürren. 1000 w. Sci Am—Nov. 12, 1904. No. 66009.

Cars.

Double Deck Cars with Covered Tops. An illustrated review of current British practice. 4400 w. St Ry Rev—Nov. 20, 1904. No. 66321 C.

Discussion.

Discussion at St. Louis, Sept. 14, 1904, on "Different Methods and Systems of Using Alternating Current in Electric Railway Motors." 10,600 w. Trans Am Inst of Elec Engrs—Nov., 1904. No. 66091 D.

Electric Locomotives.

See Railway Engineering, Motive Power and Equipment.

Electrification.

Electrification of Railways. A statement showing the great increase in tramway passengers carried in the United Kingdom since the introduction of electricity, with a comparison of the positions of the railways and tramways, and conclusions. 1700 w. Elec Rev, Lond—Oct. 28, 1904. No. 65978 A.

Express Business.

Freight and Express Business of the Interurban Railway & Terminal Co. An illustrated article giving an account of the development of this business in Cincinnati and vicinity. 5000 w. St Ry Rev—Oct. 20, 1904. No. 65892 C.

Gear Ratio.

The Effect of Changing the Gear Ratio on a Series Railway Motor Equipment. J. C. Huffman. Considers a practical case, and concludes that the best gear ratio to use on a given equipment for a given schedule speed is the lowest gearing that with a fair margin will maintain the specified schedule. 1700 w. St Ry Jour—Oct. 29, 1904. No. 65864 C.

German Practice.

Changes in German Electric Railway Practice During the Past Year. A review of changes in construction, equipment and methods, and related matters of interest. 3800 w. St Ry Jour—Nov. 5, 1904. No. 65943 C.

Illinois.

Sterling, Dixon & Eastern Electric Railway. Illustrated description of this line along the Rock River, in Illinois. 2500 w. St Ry Rev—Nov. 20, 1904. No. 66318 C.

Interurban.

The Westinghouse Single-Phase A. C. Railway System for Interurban Service. Brief, illustrated description of the system of control and wiring as used at present. 2400 w. St Ry Jour—Nov. 5, 1904. No. 65945 C.

Lubrication.

Lubrication of Street Railway Motors. W. H. Pope. Remarks on the growing practice of using oil instead of grease, with illustrated descriptions of some of the oil cups used and statistics. 1800 w. St Ry Jour—Nov. 12, 1904. No. 66023 C.

Mountain Road.

Electric Railway with Central Friction Rail (Tramway Electrique avec Mècanisme d'Adherence à Roues Horizontale et Rail Central). A. Dumas. Describing the railway at La Bourboule, Puy de Dôme, France, using the Fell system of a central double-head rail gripped between the horizontal driving wheels. 1500 w. 1 plate. Gènie Civil—Oct. 22, 1904. No. 66212 D.

N. Y. Subway.

The New York Subway Under the East River. An illustrated description of this part of the work, the methods of construction, and general information of interest. 700 w. Ir Age—Nov. 10, 1904. No. 65991.

Noise.

Concerning Noise in the Operation of Elevated Railways. Describes the plan of J. B. Strauss for reducing the noise on the elevated lines of Chicago, with comments. 2500 w. Eng News—Nov. 17, 1904. No. 66133.

Operation.

The Operation of a Four-Motor Equipment with a Two-Motor Controller. Edward Taylor. Gives a detailed analysis of the conditions of such operation, explaining the causes of troubles. 1200 w. St Ry Jour—Nov. 12, 1904. No. 66022 C.

Paris.

Traction Systems of Paris. Paul Dubois. Brief, illustrated descriptions of some of the systems employed. The lines are controlled by many different companies, each using its own method. 3500 w. Elec Wld & Engr—Nov. 26, 1904. No. 66374.

Pipe Work.

Piping and Power Station Systems. William L. Morris. This chapter deals

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with improper piping, explaining the necessity of better systems, and suggesting methods of securing better work. Ills. 5000 w. St Ry Rev—Nov. 20, 1904. No. 66320 C.

Schedules.

The Determination of Schedules by Speed Templates. Howard S. Knowlton. Shows how the speed template may be prepared and utilized in the solution of schedule problems upon electric railways. 2800 w. St Ry Rev—Oct. 20, 1904. No. 65893 C.

Shops.

New Car House and Repair Shop at Dubuque, Iowa. Illustrated description of the arrangements for the proper maintenance of a large equipment. 2500 w. St Ry Jour—Nov. 12, 1904. No. 66021 C.

Signals.

The Signal and Telephone System on the Cable Section of the Mendel Railway (Die Signal und Telephoneinrichtung auf der Drahtseilstrecke der Mendelbahn). Karl Jordan. Describing the working methods employed on a cable incline in the Tyrol. 1800 w. Zeitschr f Elektrotechnik—Oct. 30, 1904. No. 66246 D.

The Signal System on the Subway Division, Interborough Rapid Transit Co., New York. An illustrated description of the electro-pneumatic block and interlocking system as modified to meet the severe conditions of heavy traffic on an electric railway where the rails are used for the return circuit. 3000 w. Eng Rec—Nov. 12, 1904. No. 66027.

Single Phase.

Single-Phase Electric Railway Work in Europe. A summary of the remarks of C. O. Mailloux on some investigations he had made in Europe on alternating-current railway work, contributed in the discussion of the paper by Prof. A. S. McAllister. Ills. 6600 w. St Ry Jour—Nov. 26, 1904. No. 66372 C.

Stray Currents.

See Civil Engineering, Water Supply.

Switzerland.

The St. Gall-Speicher-Trogen Electric Railway. S. Herzog. Illustrated detailed description of a recently constructed railway driven by direct current obtained through transformers and converters from the three-phase 10,000-volt supply coming from the Kubelwerk. 2000 w. St Ry Rev—Nov. 20, 1904. No. 66319 C.

Terminal Building.

Indianapolis Traction Terminal Building. Illustrated description of a recently completed building, said to be the most modern and complete electric terminal railway station in the world. 1000 w. St Ry Jour—Nov. 12, 1904. No. 66020 C.

Test Car.

The Autographic Test Car. Albert B. Herrick. Illustrated description of a car for testing and making defective bonds automatically, and also providing a complete record of the electrical condition of the return circuit. 2000 w. St Ry Jour—Nov. 26, 1904. No. 66371 C.

Tokio.

The Tokio Metropolitan Railway. Describes in detail a new line, wholly in bank or viaduct, through the heart of the city. Ills. 2500 w. Engng—Nov. 11, 1904. No. 66197 A.

Tracks.

Notes on Permanent Way for Tramways. A. N. Connett. An analysis of proportionate costs, with discussion of construction details. 5000 w. Elect'n, Lond—Nov. 4, 1904. No. 66044 A.

Traction Resistance.

Tractive Force and Grade Reduction in Street Curves (Zugkraft und Neigungsreduktion in Strassenkurven). K. Nussbaumer. A mathematical investigation of the relations between curve and grade resistances on street railways. 2000 w. Schweizerische Bauzeitung—Nov. 5, 1904. No. 66228 B.

Tramway Economics.

The Economics of Electric Tramways in Britain. Robert H. Smith. Tabulated statistics and general information of a number of British lines. 3000 w. Engr, Lond—Nov. 11, 1904. No. 66302 A.

Tramways.

Leeds, Wakefield and West Riding Tramways. Illustrates and describes an extensive system of electric tramways in England. 2000 w. Elec Engr, Lond—Nov. 11, 1904. No. 66193 A.

Permanent Way for Tramways. Charles T. Taylor. Read before the Rugby Engng Soc. Discusses rails, special work, foundation, paving, etc. Ills. 5000 w. Mech Engr—Nov. 19, 1904. No. 66354 A.

Troubles.

Some Power Plant Experiences. H. C. Reagan. A review of difficulties and accidents in an interurban power station near New York. 1800 w. St Ry Rev—Nov. 20, 1904. No. 66322 C.

Underground.

New York's Great Underground Railway. An illustrated article giving the history of the undertaking, the route, construction, track, stations, lighting, rolling stock, signaling, etc. 11400 w. Tram & Ry Wld—Nov. 10, 1904. No. 66355 B.

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THE PUBLICATIONS REGULARLY REVIEWED AND INDEXED.

The titles and addresses of the journals regularly reviewed are given here in full, but only abbreviated titles are used in the Index. In the list below, *w* indicates a weekly publication, *b-w*, a bi-weekly, *s-w*, a semi-weekly, *m*, a monthly, *b-m*, a bi-monthly, *t-m*, a tri-monthly, *qr*, a quarterly, *s-q*, semi-quarterly, etc. Other abbreviations used in the index are: Ill—Illustrated; W—Words; Anon—Anonymous.

Alliance Industrielle. *m.* Brussels.
American Architect. *w.* Boston.
American Electrician. *m.* New York.
Am. Engineer and R. R. Journal. *m.* New York.
American Jl. of Science. *m.* New Haven, U.S.A.
American Machinist. *w.* New York.
Annales des Ponts et Chaussées. *m.* Paris.
Ann. d Soc. d Ing. e d Arch. Ital. *w.* Rome.
Architect. *w.* London.
Architectural Record. *qr.* New York.
Architectural Review. *s-q.* Boston.
Architect's and Builder's Magazine. *m.* New York.
Australian Mining Standard. *w.* Sydney.
Autocar. *w.* Coventry, England.
Automobile. *m.* New York.
Automobile Magazine. *m.* New York.
Automotor Journal. *w.* London.
Beton und Eisen. *qr.* Vienna.
Brit. Columbia Mining Rec. *m.* Victoria, B. C.
Builder. *w.* London.
Bulletin American Iron and Steel Asso. *w.* Philadelphia, U. S. A.
Bulletin de la Société d'Encouragement. *m.* Paris.
Bulletin of Dept. of Labor. *b-m.* Washington.
Bull. Soc. Int. d Electriciens. *m.* Paris.
Bulletin of the Univ. of Wis., Madison, U. S. A.
Bulletin Univ. of Kansas. *b-m.* Lawrence.
Bull. Int. Railway Congress. *m.* Brussels.
California Jour. of Tech. *m.* Berkeley, Cal.
Canadian Architect. *m.* Toronto.
Canadian Electrical News. *m.* Toronto.
Canadian Engineer. *m.* Toronto and Montreal.
Canadian Mining Review. *m.* Montreal.
Cassier's Magazine. *m.* New York.
Cement. *b.-m.* New York.
Cement Age. *m.* New York.
Central Station. *m.* New York.
Chem. Met. Soc. of S. Africa. *m.* Johannesburg.

Colliery Guardian. *w.* London.
Compressed Air. *m.* New York.
Comptes Rendus de l'Acad. des Sciences. *w.* Paris.
Consular Reports. *m.* Washington.
Deutsche Bauzeitung. *b-w.* Berlin.
Domestic Engineering. *m.* Chicago.
Electrical Engineer. *w.* London.
Electrical Review. *m.* London.
Electrical Review. *w.* New York.
Electrical World and Engineer. *w.* New York.
Electric Club Journal. *m.* Pittsburg, Pa.
Electrician. *w.* London.
Electricien. *w.* Paris.
Electricity. *w.* London.
Electrochemical Industry. *m.* New York.
Electrochemist and Metallurgist. *w.* London.
Elektrochemische Zeitschrift. *m.* Berlin.
Elektrotechnische Zeitschrift. *w.* Berlin.
Elettricita. *w.* Milan.
Engineer. *w.* London.
Engineer. *s-m.* Chicago.
Engineering. *w.* London.
Engineering and Mining Journal. *w.* New York.
Engineering Magazine. *m.* New York & London.
Engineering News. *w.* New York.
Engineering Record. *w.* New York.
Engineering Review. *w* London.
Eng. Soc. of Western Penna. *m.* Pittsburg, U.S.A.
Engineering Times. *m.* London.
Fire and Water. *w.* New York.
Foundry. *m.* Cleveland, U. S. A.
Génie Civil. *w.* Paris.
Gesundheits-Ingenieur. *s-m.* München.
Giorn. Dei Lav. Pubb. e. d. Str. Ferr. *w.* Rome.
Glaser's Ann. f Gewerbe & Bauwesen. *s-m.* Berlin.
Ice and Refrigeration. *m.* New York.
Ill. Zeitschr. f. Klein u. Strassenbahnen. *s-m.* Berlin.
Ingenieria. *b-m.* Buenos Ayres.
Ingenieur. *w.* Hague.
Insurance Engineering. *m.* New York.
Iron Age. *w.* New York.
Iron and Coal Trades Review. *w.* London.
Iron and Steel Metallurgist. *m.* Boston.
Iron and Steel Trades Journal. *w.* London.
Iron Trade Review. *w.* Cleveland, U. S. A.
Jour. Am. Foundrymen's Assoc. *m.* New York.
Journal Asso. Eng. Societies. *m.* Philadelphia.
Journal of Electricity. *m.* San Francisco.
Journal Franklin Institute. *m.* Philadelphia.
Journal of Gas Lighting. *w.* London.
Journal Royal Inst. of Brit. Arch. *s-qr.* London.
Jour. Roy. United Service Inst. *m.* London.
Journal of Sanitary Institute. *qr.* London.
Jour. of South African Assn. of Engineers. *m.* Johannesburg, S. A.
Journal of the Society of Arts. *w.* London.
Journal of U. S. Artillery *b-m.* Fort Monroe,U.S.A.
Journal Western Soc. of Eng. *b-m.* Chicago.
Journal of Worcester Poly. Inst., Worcester, U.S.A.
Locomotive. *m.* Hartford, U. S. A.
Locomotive Engineering. *m.* New York.
Machinery. *m.* New York.
Madrid Cientifico. *t-m.* Madrid.
Marine Engineering. *m.* New York.
Marine Review. *w.* Cleveland, U. S. A.
Mem. de la Soc. des Ing. Civils de France. *m.* Paris.
Métallurgie. *w.* Paris.
Minero Mexicano. *w.* City of Mexico.
Minerva. *w.* Rome.
Mines and Minerals. *m.* Scranton, U. S. A.
Mining and Sci Press. *w.* San Francisco.
Mining Magazine. *m.* New York.
Mining Reporter. *w.* Denver, U. S. A.
Mittheilungen des Vereines für die Förderung des Local und Strassenbahnwesens. *m.* Vienna.
Mouvement Maritime. *w.* Brussels.
Municipal Engineering. *m.* Indianapolis, U. S. A.
Municipal Journal and Engineer. *m.* New York.
Nature. *w.* London.
Nautical Gazette. *w.* New York.
New Zealand Mines Record. *m.* Wellington.
Nineteenth Century. *m.* London.
Oest. Wochenschr. f. d. Oeff. Baudienst. *w.* Vienna.
Oest. Zeitschr. Berg- & Hüttenwesen. *w.* Vienna.
Page's Weekly. *w.* London.
Plumber and Decorator. *m.* London.
Popular Science Monthly. *m.* New York.
Power. *m.* New York.
Practical Engineer. *w.* London.
Pro. Am. Soc. Civil Engineers. *m.* New York.
Pro. Canadian Soc. Civ. Engrs. *m.* Montreal.
Proceedings Engineers' Club. *qr.* Philadelphia.
Pro. St. Louis R'way Club. *m.* St. Louis, U. S. A.
Public Works. *m.* London.
Quarry. *m.* London.
Queensland Gov. Mining Jour. *m.* Brisbane, Australia.
Railroad Gazette. *w.* New York.
Railway Age. *w.* Chicago.
Railway & Engineering Review. *w.* Chicago
Review of Reviews. *m.* London & New York.
Revista d Obras. Pub. *w.* Madrid.
Revista Tech. Ind. *m.* Barcelona.
Revue de Mécanique. *m.* Paris.
Revue Gen. des Chemins de Fer. *m.* Paris.
Revue Gen. des Sciences. *w.* Paris.
Revue Industrielle. *w.* Paris.
Revue Technique. *b-m.* Paris.
Revue Universelle des Mines. *m.* Liége.
Rivista Gen. d Ferrovie. *w.* Florence.
Rivista Marittima. *m.* Rome.
Schiffbau. *s-m.* Berlin.
Schweizerische Bauzeitung. *w.* Zürich.
Scientific American. *w.* New York.
Scientific Am. Supplement. *w.* New York.
Sibley Jour. of Mech. Engng. *m.* Ithaca, N. Y.
Stahl und Eisen. *s-m.* Düsseldorf.
Stevens' Institute Indicator. *qr.* Hoboken, U.S.A.
Street Railway Journal. *m.* New York.
Street Railway Review. *m.* Chicago.
Tijds. v h Kljk. Inst. v Ing. *qr.* Hague.
Traction and Transmission. *m.* London.
Tramway & Railway World. *m.* London.
Trans. Am. Ins. Electrical Eng. *m.* New York.
Trans. Am. Ins. of Mining Eng. New York.
Trans. Am. Soc. Mech. Engineers. New York.
Trans. Inst. of Engrs. & Shipbuilders in Scotland, Glasgow.
Transport. *w.* London.
World's Work. *m.* New York.
Yacht. *w.* Paris.
Zeitschr. d. Mitteleurop. Motorwagen Ver. *s-w.* Berlin.
Zeitschr. d. Oest. Ing. u. Arch. Ver. *w.* Vienna.
Zeitschr. d. Ver. Deutscher Ing. *w.* Berlin.
Zeitschrift für Elektrochemie. *w.* Halle a S.
Zeitschr. f. Elektrotechnik. *w.* Vienna.